
BCN BIOREFINING CONVERSIONS NETWORK
CHANGING THE NATURE OF BIOMASS
Alberta Innovates Bio Solutions
5th Annual BCN Strategic Retreat
Mobilizing Alberta's Bioeconomy
Fairmont Banff Springs Hotel, Banff, Canada
October 21-23, 2014

Welcome from the BCN

Dear Esteemed Colleagues,

Welcome to the 5th Annual Strategic Retreat organized by the Biorefining Conversions Network (BCN) at the beautiful Fairmont Banff Springs Hotel in Banff, Alberta, Canada. The past year was exciting for the BCN as we saw noticeable growth and accomplishments in the local and global bioindustrial markets. We anticipate many more beneficial developments in R&D and commercialization of technology in the future and look forward to extending our network through collaborations.

Alberta has a strong potential to become a bioindustrial powerhouse due to its thriving agricultural, forestry, energy, and oil & gas sectors. Its ideal location also provides an opportunity for the province to utilize available feedstocks, resources, and infrastructure. This year's retreat, titled *Mobilizing Alberta's Bioeconomy*, will explore the future of these different sectors and how we may work collaboratively to move forward and build a sustainable bioeconomy.

We are excited about the talks and panel discussions this year, which will feature international speakers from various corners of the bioeconomy. The opening keynote addresses, as well as the closing plenary lecture, promise to be informative and inspiring. The first session will explore the capital and investment aspects of commercialization. In the subsequent session, we will examine the bioeconomy in Alberta with presentations from many Alberta-based companies. The second day will include thought-provoking discussions from members of the oil & gas sector, as well as the value-added chemical industries. We also invite you to participate in our silent auction to support a Graduate Bioindustrial Endowment established in the Faculty of Agricultural, Life & Environmental Sciences at the University of Alberta. As with all of our strategic retreats, we encourage all of our participants to take advantage of this setting to network and develop ideas, businesses, and collaborations.

Over the course of the retreat, I look forward to reconnecting with many of you, and meeting some of you for the first time. I hope you will enjoy productive and engaging sessions in the picturesque setting of Banff, Canada.

Sincerely,

David Bressler
Executive Director, Biorefining Conversions Network

ACKNOWLEDGEMENTS

We would like to thank our primary funder and main supporter for this event, Alberta Innovates Bio Solutions, as well as the Government of Alberta and the University of Alberta for being strong supporters of the BCN:

Gold Sponsors:

The **Northern Alberta Institute of Technology**'s (**NAIT**) vision is to aspire to be the most relevant and responsive post-secondary institution in Canada and one of the world's leading polytechnics.

"a leading polytechnic committed to student success"

NAIT's hands-on, technology-based education and applied research are essential to the productivity and prosperity of Alberta. We contribute to Alberta's economy in significant ways. Our graduates have the knowledge, skills and entrepreneurial spirit that serve to increase the province's competitiveness. Most NAIT grads stay in the province, actively engaging in the labour force. NAIT's commitment to applied research means quicker-to-market solutions for our industry partners.

Established in 1913, **Olds College** is located in the heart of central Alberta, just a stone's-throw away from the Rocky Mountains. When Olds College first opened its doors 100 years ago it was as an agricultural college specializing in teaching men to farm, and teaching women about home economics. Since then, that focus has evolved and Olds College has become a leader in the post-secondary study of Agriculture, Agri-Business, Horticulture, Animal Sciences, Trades and Fashion.

The Olds College main campus covers over 2000 acres, and includes the Brewery, grain farm, beef feedlot, equine stables and arenas, the Community Learning Campus, the National Meat Institute, and the Olds College Centre for Innovation. Our second campus, located in Calgary, Alberta, is home to The Fashion Institute.

Olds College is a unique learning environment, focusing on 'hands-on learning' as a way to empower learners and develop rural communities. The college has embraced innovation, including being the first North American college to develop a gamified curriculum, including state of the art technologies, iPads in all classes, and ensuring that our students graduate from our programs with the tools that the next generation will need to become leaders in industry. Olds College is the leading centre of specialization in agriculture, horticulture, entrepreneurship and land-based education, and applied research at the college level in Canada.

GenomeCanada

Genome Canada is a catalyst for developing and applying genomics and genomic-based technologies that create economic and social benefit for Canadians. Genome Canada: connects ideas and people across public and private sectors to find new uses for genomics; invests in large-scale science and technology to fuel innovation; and, translate discoveries into applications, new technologies, societal impacts and solutions across key sectors of national importance, including health, agriculture, forestry, fisheries & aquaculture, energy, mining, and the environment. For more information, visit http://www.genomecanada.ca/.

GenomeAlberta

Genome Alberta is a publicly funded organization that initiates, funds, and manages genomics research and partnerships. We are based in Calgary but lead projects around the province and participate in a variety of projects across the country. We are one of Canada's six Genome Centres and work closely with these centres to advance the science and application of genomics, metabolomics, and many other related 'omics'. We have leveraged funding to create 127 million dollars in funding for genomics research since our inception in 2005. More information at http://genomealberta.ca.

bio alberta

BioAlberta is the central voice and organizing hub for life science industries in Alberta. The association's vision is to create a thriving and competitive life sciences industry that fuels key sectors of Alberta's economy. BioAlberta is a private, not-for-profit industry association, representing more than 140 members of Alberta's steadily increasing life science industry's producers, users and supporters in the province. These member companies operate in specialized sectors such as health biotechnology and pharmaceuticals, medical technology and devices, agricultural biotechnology, natural health products and nutraceuticals, environmental biotechnology and industrial biotechnology and bioprocessing. BioAlberta's activities are focused on advocacy, promotion and proactively facilitating the growth of Alberta's life sciences industry. For more information, go to: www.bioalberta.com.

As a full-service technology provider, **PSAV** produces all aspects of events, from networking HSIA to overhead rigging to 3-D projection mapping to hybrid meetings. Our 4,750+ full-time professionals receive on-going training through our unrivaled development program, ensuring our events are produced using the latest technology trends. Founded with a strong commitment for innovation and creativity, PSAV is the comprehensive supplier for all your event needs.

With locations in more than 1,300 destination resorts and hotels throughout the U.S., Canada, Mexico, Europe and the UAE, PSAV is the leading in-house audiovisual provider in the industry. Our large network provides unmatched depth of resources in terms of local equipment and team members, enabling us to quickly accommodate last-minute requests faster than anyone else.

We've been building our international reputation for more than three quarters of a century. PSAV can trace its roots back to 1937, when Mr. P. Ray Swank and his wife, Lucille Swank, founded Swank Audio Visuals, a company that merged with PSAV in 2012. The company began in St. Louis as a "portable projection service," predating technology such as color television, FM radio, 8-tracks and audio tape.

In the 1990s, PSAV consolidated leading regional AV companies to meet a growing demand for a single source of consistent, high-quality event technology support. Decades later, our commitment to FLawless EXecution®, exceptional customer service and dramatic results remains unchanged.

Silver Sponsors:

The Edmonton Waste Management Centre (EWMC) is a unique collection of advanced waste processing and research facilities. Owned and operated by the Waste Management Services of the City of Edmonton, the EWMC is an integral part of Edmonton's sustainable approach to waste management. The goal is to divert 90% of all residential waste materials from landfill by 2016. This is being accomplished by the addition of a waste-to-biofuels component to the traditional waste reduction, recycling, and composting programs.

The Advanced Energy Research Facility (AERF) is a new R&D Facility leading the way in biofuel production from waste. The AERF was built with joint funding from the City of Edmonton and Alberta Innovates – Energy and Environment Solutions (AI-EES). AERF is part of a comprehensive waste-to-biofuels project at the Edmonton Waste Management Centre that also includes a waste processing facility owned and operated by the City of Edmonton and a commercial waste-to-biofuels facility, owned and operated by Enerkem Alberta Biofuels Inc. (EAB).

The AERF offers unique research and development capabilities to test diverse feedstocks for gasification and for production of higher value liquid products from syngas. The facility includes a waste feedstock preparation system, a state of the art 300 kg/hr pilot gasification system, including a gas conditioning, cleaning and methanol synthesis system, and a bench scale gas-to-liquids catalytic research laboratory and analytical equipment. Examples of companies who are actively doing work in the AERF are Enerkem and Forge Hydrocarbons.

Waste Management Services of the City of Edmonton is a proud sponsor of the BCN event and is looking forward to grow the bioconversion industry in Alberta.

Enerkem makes biofuels and renewable chemicals from waste. With its proprietary technology, Enerkem converts non-recyclable municipal solid waste (MSW) into methanol, ethanol and other widely used chemical intermediates. This transformative technology can convert chemically and structurally heterogeneous waste materials (such as MSW) into a chemical-grade syngas, and then, turn it into renewable chemicals or biofuels using catalysts.

Enerkem will begin producing biomethanol in the coming weeks at one of the first commercial biorefineries in North America. This game-changing facility, which was built in partnership with the City of Edmonton, will convert the City's MSW into methanol and ethanol – building blocks for olefins and acrylates. The City is seeking to increase its waste diversion rate from 60% to 90%.

Enerkem is developing additional biorefineries in North America and globally, based on its modular manufacturing approach. Its technology and facilities help diversify the energy mix and make greener everyday products while offering a sustainable alternative to landfilling and incineration. www.enerkem.com

Every year the **Climate Change and Emissions Management Corporation** (**CCEMC**) provides millions of dollars in funding for projects that will help to reduce greenhouse gas emissions.

So far, the organization has committed more than $237.5 million in funding to nearly 100 projects.

Partnering with Alberta Innovates Bio Solutions (AI Bio), the CCEMC launched the Biological GHG Management Program in May 2012. The program is fulfilling part of CCEMC's mandate to reduce greenhouse gas emissions and the AI Bio mandate to grow and develop Alberta's bio-industries through science and innovation. The program offers financial support for projects that will discover, develop and deploy technologies and strategies and demonstrate cost-effective ways for the agriculture, forestry and waste management sectors to help address Alberta's climate change strategy.

Funding for the CCEMC is sourced from Alberta's large industrial emitters. In Alberta, large emitters have a mandatory legislated requirement to achieve specified reductions of greenhouse gases. If they're unable to reach their target, one option is to pay a levy of $15 per tonne into the Climate Change and Emissions Management Fund. The fund is administered by the Government of Alberta and the CCEMC receives grants from the fund to support its work.

Alberta's Industrial Heartland is one of the world's most attractive locations for chemical, petrochemical, oil, and gas investment. It is also Canada's largest hydrocarbon processing region. The region's 40+ companies, several being world scale, provide fuels, fertilizers, power, petrochemicals and more to provincial and global consumers.

Alberta's Industrial Heartland is guided by a non-profit association of municipalities (City of Fort Saskatchewan, Lamont County, Strathcona County, Sturgeon County and the City of Edmonton) dedicated to sustainable eco-industrial development. Alberta's Industrial Heartland Association (AIHA) was created in 1998 by the municipalities who each had land within the geographic area of Alberta's Industrial Heartland.

A leading principal of AIHA is promoting responsible development within the region. This includes ensuring the region is ready for development in its infrastructure, services, and land use zoning principles. AIHA recognizes that activities in the area can have a major impact on neighboring communities and affect their service delivery as well. Together, the municipalities take a proactive and cooperative approach to planning and industrial development.

The **Faculty of Science at the University of Alberta** is one of Canada's top academic units and provides a vibrant learning environment for the discovery, dissemination, and application of new scientific knowledge through teaching and learning, research and creative activity, community involvement, and partnerships with government and industry. Science is home to over 6000 undergraduates, 1100 graduate students and over 300 academic staff. The Faculty of Science is a research powerhouse, and Science researchers attract more than $70M in funding from a broad array of funding agencies, including NSERC, CIHR, SSHRC, Alberta Innovates, industry, NGOs and many other stakeholders and partners. The faculty includes world leaders in many fields of research and scientific discovery, and 52 professors in the Faculty of Science hold externally funded chairs including Canada Research Chairs, a Canada Excellence Research Chair, iCORE chairs, CAIP chairs, and a range of other endowed and industry-funded chairs. The Faculty of Science comprises seven departments: Biological Sciences, Chemistry, Computing Science, Earth and Atmospheric Sciences, Mathematical and Statistical Sciences, Physics and Psychology. Science also hosts 11 Centres and Institutes for advanced research including the Alberta Centre for Earth Observation Sciences, the Alberta Glycomics Centre, Alberta Innovates Centre for Machine Learning, Applied Mathematics Institute, Canadian Centre for Isotopic Microanalysis, Centre for Mathematical Biology, Centre for Particle Physics, Institute for Geophysical Research, Institute for Space Science Exploration and Technology, Statistics Centre and the Theoretical Physics Institute.

The world's most complex problems will not be solved in silos. The **Faculty of Agricultural, Life & Environmental Sciences** (ALES) **at the University of Alberta** draws on science, social sciences and business, to tackle some of the world's most important challenges. Research is conducted within four themes: bioresource innovation, environmental sustainability, food and nutritional security, and individual and community well-being.

Composed of four departments – Agricultural, Food & Nutritional Science, Renewable Resources, Resource Economics & Environmental Sociology, and Human Ecology – and the Devonian Botanic Garden, ALES' research encompasses the physical, biological, and social sciences.

Science and policy are linked in ALES. Causes and solutions for local problems are increasingly determined by global forces and proactive strategies must replace responses at all levels from science, public policy and practice.

ALES is a research intensive faculty, with $40 million in research funding annually. Researchers have access to world-class facilities and laboratories, and graduate students work alongside global leaders and industry mavens to find comprehensive real-world solutions to some of the planet's most pressing issues.

The Faculty of ALES is celebrating its centenary in 2014-15.

The **University of Alberta's School of Energy and the Environment** (**SEE**) brings together the University's unique and extensive combination of expertise in diverse areas – engineering, science, arts, agriculture, native studies, business, law, public health, medicine and others – in a virtual environment where participants conduct research, undertake interdisciplinary education and cultivate and contribute to worldwide discussions on critical issues surrounding environment, energy and the economy.

NSERC programs fund researchers at Canada's universities and colleges to work with companies on your pressing business challenges. University and college researchers help companies solve identify potential solutions to R&D challenges, benefit from fresh ideas and new talent or identify potential future employees by placing students into your business, and provide access to expertise, facilities and specialized equipment.

NSERC's suite of targeted partnership offerings can address short, medium or long term challenges, and even enable businesses to meet and try working with a research team for the first time.

Over 3000 small, medium and large companies in all sectors work through NSERC every year to success solve business, product and process issues. Learn more about how NSERC's business opportunities can help your business grow. Contact the NSERC regional office nearest you at 1-888-767-1767 or visit our website: www.nsercpartnerships.ca.

We would also like to thank:

- All of our speakers, panellists, and moderators for agreeing to participate in this event and for sharing their knowledge and expertise
- Our event volunteers for their time and assistance The Fairmont Banff Springs Hotel staff for their event coordination support, willingness to accommodate, and attention to detail
- Ali Powers of BioAlberta

BIO-INDUSTRIAL LEADER OF TOMORROW SCHOLARSHIP & ENDOWMENT

The Bio-Industrial Leader of Tomorrow Scholarship & Endowment was created in 2014 by the Faculty of Agricultural, Life & Environmental Sciences (ALES). The award is given out annually on the basis of superior academic achievement and leadership qualities to a student registered full-time in a graduate degree program in the Faculty of ALES. Preference is given to applicants from the Department of Agricultural, Food & Nutritional Science carrying out bio-industrial research on biomass conversion technologies including value-added opportunities that have positive social, economic and environmental impacts. Preference will also be given to applicants whose research focuses on the production of industrial material, fuel, or chemical applications. The scholarship is expected to help Alberta maintain a leadership role in the bio-industry, which is expected to grow from $154 billion to $550 billion by 2025.

This year, the BCN is running a silent auction to raise money for this scholarship and endowment. We would like to thank the following contributors for donating items for the silent auction:

And many more...

AGENDA

Tuesday, October 21, 2014 (Stanley Thompson Foyer)	
7:00pm – 9:00pm	**Registration and Networking Reception**
Wednesday, October 22, 2014 (Van Horne Ballroom)	
7:15am – 8:45am	**Breakfast**
Opening Comments	
8:45am – 9:00am	David Bressler – Executive Director, BCN Brad Anderson – Executive Director, Alberta Chamber of Resources
Opening Keynotes	
9:00am – 9:30am	Jim Lane - Editor, Biofuels Digest
9:30am – 10:00am	Peter Riddles – Founder & Director, ViciBio
10:00am – 10:30am	**Power Break**
Session 1: *Riding the VC Wave Over the Valley of Death* Session Chair: Jim Lane – Editor, Biofuels Digest	
10:30am - 12:00pm	Denver Dale – Founder & CEO, On-Point Capital Conrad Plimpton – Managing Director, Plimpton & Company Kaizad Debu – Associate Portfolio Manager, AIMCo **Panel Discussion**
12:00pm –12:45pm	**Lunch**
12:45pm – 3:00pm	**Mountain Break**
Session 2: *The Alberta Bioindustry: What's on the Horizon?* Session Chair: Warren Mabee – Canada Research Chair in Renewable Energy Development and Implementation, Queen's University	
3:00pm – 4:15pm	Jonathan Curtis – Professor, University of Alberta William Bardosh – CEO, TerraVerdae Bioworks Mike Hamilton – CEO, Renmatix
4:15pm – 4:45pm	**Power Break**
4:45pm – 6:00pm	Roberto Armenta – CTO, Mara Renewables Corp. David Lynch – General Manager, R&D, Enerkem Inc. Tim Haig & David Bressler – CEO & Chief Scientific Advisor, Forge Hydrocarbons
6:15pm – 9:00pm	**Mountview BBQ Dinner** Buses will depart from the front of the Fairmont Banff Springs at 6:15pm and 6:20pm

Thursday, October 23, 2014 (Van Horne Ballroom)	
7:30am–8:45am	**Breakfast**
Session 3a: *The Corner of Bioindustry St. and Oil & Gas Ave.* Session Chair: Susan Wood-Bohm – Executive Director, Biological GHG Management	
8:45am – 9:35am	Lisa Dyson – CEO, Kiverdi Ian Thomson – President, Western Canada Biodiesel Association
Perspectives of Funders	
9:35am – 9:50am	Adrianna Clapp – Program Coordinator, Genome Alberta Irene Mikawoz – Manager, Prairies Regional Office, NSERC
9:50am – 10:30am	**Power Break**
Session 3b: *The Corner of Bioindustry St. and Oil & Gas Ave.* Session Chair: Susan Wood-Bohm – Executive Director, Biological GHG Management	
10:30am – 11:45am	Neil Shelly – Executive Director, Alberta's Industrial Heartland Brad West – Director of Business Development, Renewable Energy, Suncor Energy Services Inc. Juan Benitez – Senior Specialist, Strategic Partnerships, Cenovus Energy **Panel Discussion**
11:45am – 1:00pm	**Lunch & Oral Competition for Graduate Students and Postdocs**
1:00pm – 3:00pm	**Mountain Break**
Session 4: *Plugging into the "Receptor" Industry* Session chair: Bill Orts – Research Leader, United States Department of Agriculture	
3:00pm – 4:25pm	Aaron Thornton – Global Marketing Manager, Biorenewables, BASF Joseph Matt – Technology Development Specialist, Croda Inc. Alexander Thiemann – Manager of Scientific Affairs, Dr. Straetmans GmbH Albert Soley – R&D Project Manager, Lipotec Ben Tungland – President, Ostrem Chemical Co. Ltd.
4:25pm – 4:45am	**Power Break**
4:45pm – 5:30pm	**Panel Discussion**
Closing Plenary	
5:30pm – 6:30pm	Darrell Bricker – CEO for Ipsos, Global Public Affairs
6:30pm – 7:30pm	**Networking Reception & Silent Auction (Riverview Lounge)**
7:30pm – 9:00pm	**Banquet Dinner (Alberta Room)**
End of Retreat	

OPENING KEYNOTES

Jim Lane

Editor, Biofuels Digest

Jim Lane is editor & publisher of Biofuels Digest, the world's most widely-read bioeconomy daily. He writes for more than 1 million readers in 190 countries on sustainability, and clean alternatives in fuels, chemicals, energy and materials. His Florida-based media company, Ascension Publishing, produces conferences and data services as well as newsletters and websites.

BiofuelsDigest
The world's most widely read biofuels daily

Dr. Peter Riddles

Founder and Director, ViciBio

A respected international leader in innovation, Dr. Riddles seeks to contribute to sustainable economic development through realizing the benefits of science. He has accumulated diverse international experiences advising governments on innovation strategies and working with individual companies, often as Board Director or Advisor.

He has contributed to the preparation of innovation strategies in New Zealand, Australia, Canada and California, and presently is a member of the Alberta Research and Innovation Authority (ARIA), a Board Member of the Commonwealth Scientific and Industrial Organization (CSIRO) and a Fellow of the California Technology Council. He was the Foundation President of AusBiotech and a member of many Australian government advisory councils including the Industrial Research and Development Board, Innovation Australia Board and the Queensland Biotechnology Advisory Council.

He is an experienced chairman/advisor of companies involved in life sciences in diverse sectors including medical technology, biotechnology and agriculture. He presently is Chairman of Life Sciences Queensland Ltd, Wound Management Innovation Pty Ltd, and Griffith University Enterprise and advises a number of start-ups and entrepreneurs. Recently, he has been working in “social enterprise” including as Director of Hear and Say for Deaf Children Pty Ltd.

Dr. Riddles has a PhD (The University of Queensland), Graduate Diplomas in Business (Innovation) and in Corporate Governance, was a Fellow in Biochemistry at Stanford University, and is Fellow of the Australian Institute for Company Directors. He was awarded Honorary Life Member of AusBiotech and the Queensland Life Sciences Industry Excellence Award.

SESSION ONE

RIDING THE VC WAVE OVER THE VALLEY OF DEATH

Jim Lane (Session Chair)

Editor, Biofuels Digest

Jim Lane is editor & publisher of Biofuels Digest, the world's most widely-read bioeconomy daily. He writes for more than 1 million readers in 190 countries on sustainability, and clean alternatives in fuels, chemicals, energy and materials. His Florida-based media company, Ascension Publishing, produces conferences and data services as well as newsletters and websites.

BiofuelsDigest
The world's most widely read biofuels daily

Dr. Denver Dale

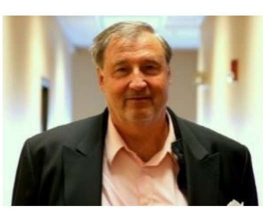
CEO, On-Point Capital

Denver is the founder and CEO of On-Point Capital LLC, an investment management firm that provides specialized investment services to a select group of significant investors. In this capacity, Denver sets overall strategy for the firm and leads investment platform design, development and execution.

OPC is currently launching a series of expert venture capital funds focused at the intersection of advanced biotechnologies and major bio-industrial sectors, including Agriculture, Food, Beverage, Bioenergy, Chemicals, Materials, Cleantech and Healthcare. OPC's platform has been carefully designed to provide investors with a specialized investment vehicle through which to exploit the enormous economic and sustainability potential of advanced biotechnologies.

Prior to forming OPC, Denver ran an elite investment unit within Goldman Sachs & Co. directly managing more than US $4 billion on behalf of a small number of significant investors. In addition, Denver has been the founder and CFO of several technology-enabled businesses where he designed and managed global operations, investor relations, client services and business development.

Denver has a Ph.D. in biomedical sciences from Oxford University and a B.Sc. (Honours) in medical and marine biology from the University of Queensland, Australia.



Conrad Plimpton

Managing Director, Plimpton and Company

For fifty years, Conrad's career has been marked by an emphasis on innovation and entrepreneurship, with an appreciation for applied science and technology. He received his A.B. in Physics from Harvard College, where he studied high energy accelerator physics and microwave laser studies in physical chemistry under Nobel Prize winner Prof Norman Ramsey. Conrad continued his studies at the University of Chicago, where he received his Master's degree in Astrophysics and Space Research under Professor Chandraskhar (also a Nobel Prize winner), followed by his M.B.A. in Finance and Marketing, studying under Professor Fama (also a Nobel Prize winner).

He is currently active globally as the lead investor for Desert Angels in Tucson, helping a variety of universities commercialize their research. Last year, Desert Angels raised more early-stage financing for life sciences than any other region, other than Palo Alto, and is currently ranked as one of the leading angel groups in the USA. As the Managing Director of Plimpton and Company, he has headed a number of private investment and banking initiatives.

Conrad is the chair of MSDx (Tucson), which provides novel blood biomarker tools for studying neurological disease such as multiple sclerosis. Conrad founded NeuroHealth AG in Zug to fund research at University of Zurich. He also supported his Harvard classmate who founded UA neurosciences in Tucson by founding the neurosciences visiting committee, now known as Mind Brain & Behavior.

Conrad has been involved in the pharma & specialty chemical industry since 1979, when he became a founding shareholder and director of Troy Chemical, a world leader in iodine based biocides. Three years later, he became the founding chairman and owner of the Inolex Group in Philadelphia, an industrial esters manufacturer. Conrad continues to recruit and build world class management that has transformed Inolex into a world leader as an independent provider of specialty and innovative ingredients to the personal care and cosmetic industries, with broader chemistries beyond esters, including leadership in naturals.

Outside of the specialty chemical and pharmacological industries, Conrad has played critical roles at Exide Electronics (a global leader in uninterruptible power systems for large-scale applications), Comartis USA (a provider of on-line training services), Avirtek (a provider of cybersecurity algorithms originally developed for network centered warfare security), and Cibola Technologies (a developer of e-commerce and e-marketing).

Kaizad Debu

Associate Portfolio Manager, Special Opportunities,
Alberta Investment Management Corporation

Kaizad Debu is a finance and investment professional with 14 years of experience in venture capital, special situations, private equity, investment banking, and auditing across North America and Asia.

Mr. Debu is an Associate Portfolio Manager, Special Opportunities at Alberta Investment Management Corporation (AIMCo), one of Canada's largest and most diversified institutional investment managers with more than $80 billion of assets under management. AIMCo's Special Opportunities group invests globally, often in active roles, in small / mid-sized companies with high capital appreciation potential and exposure to emerging innovation and macroeconomic trends.

Prior to joining AIMCo, Mr. Debu spent his career at Citigroup Investment Banking in Toronto, Canada and in the Assurance & Advisory Business Services group of a member firm of Ernst & Young in Mumbai, India. While in India, Mr. Debu completed his Chartered Accountancy designation and holds a Bachelor of Commerce degree from the University of Mumbai.

SESSION TWO

THE ALBERTA BIOINDUSTRY: WHAT'S ON THE HORIZON?

Dr. Warren Mabee (Session Chair)

Canada Research Chair in Renewable Energy Development and Implementation, Queen's University

Warren Mabee (PhD, Toronto, 2001) is an Associate Professor in the Department of Geography at Queen's University in Kingston, Canada. He is also a Canada Research Chair (Tier 2) in Renewable Energy Development & Implementation. His research interests focus on renewable energy within the scope of Canadian energy production, and examines ways in which renewable options can be made more competitive and compatible with our existing energy supply. Of particular interest is the connection between new technologies and public policy. In these areas, he has more than 60 peer reviewed publications in journals such as Energy Policy and Renewable & Sustainable Energy Reviews. He is the Director of the Queen's Institute for Energy and Environmental Policy and Associate Task Leader of the International Energy Agency's Bioenergy Task 39 'Liquid Biofuels'.

Dr. Jonathan Curtis

Professor, University of Alberta

Professor Jonathan Curtis has been a faculty member of the University of Alberta in the Department of Agricultural, Food and Nutritional Sciences since 2007. There, he directs the Lipid Chemistry Group in applied research focusing on developing materials and chemicals from renewable lipid resources and establishing novel analytical techniques in the analysis of lipids. Prior to joining the University of Alberta, Dr Curtis worked as Director of Analytical Chemistry and Functional Food Technology at Ocean Nutrition Canada (now part of DSM) in Dartmouth, Nova Scotia and for the Canadian National Research Council in Halifax, Nova Scotia.

Dr Curtis received a BSc degree in chemistry from the University of Southampton in the UK, an MSc from University of Guelph, Canada and his PhD from Swansea University, Wales UK. He is author or co-author on more than 110 peer-reviewed publications, 3 book chapters and 6 patent applications.

William Bardosh

CEO, TerraVerdae Bioworks

William Bardosh is Founder and CEO of TerraVerdae Bioworks Inc., an industrial biotechnology company focused on developing engineered biomaterials and speciality bioactive metabolites. Bill has an extensive background in technology commercialization, R&D management and alliance development.

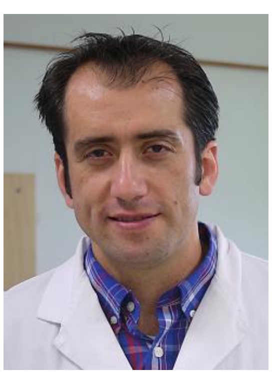
Prior to TerraVerdae, his track record includes building technology start-ups as well as major businesses within global technology firms. He held senior roles at The Jackson Laboratory, IBM, DSM and Applied Biosystems/Perkin Elmer (Life Technologies). Key accomplishments included market rollout of major technologies for Transgenics, High Performance Computing, DNA forensics and PCR/automated DNA sequencing.

Bill received his B.Sc. (Cell and Molecular Biology) and M.B.A. from Concordia University, Montreal.

Mike Hamilton

CEO, Renmatix

Mike is passionate about his vision for the future of renewable materials. Through his guidance, Renmatix is rapidly establishing itself as the leader in affordable cellulosic sugars. Mike's specialty chemical experience and market perspective is valuable as Renmatix works to accelerate bio-substitution of traditionally fossil fuel based products. His capacity to think technically and act commercially make him uniquely qualified to help Renmatix cross the gap between the science that drives economically disruptive Plantro™ sugars, and the enabling commercial benefits of the Plantrose™ process. Mike's familiarity with end markets, and established relationships with core customers, ensure a smooth runway for Renmatix beyond development and early revenue into formal licensing agreements and biorefinery production. With 20 years of demonstrated leadership as an executive at Rohm and Haas Company, serving in roles across North America, Europe, and Asia, he has established an enviable reputation for building high performing teams. Mike was raised and educated in Canada, where he earned both a bachelor's degree in chemistry and his M.B.A. at the University of Western Ontario. He currently lives in Philadelphia with his wife and four children.



Dr. Roberto Armenta

Chief Scientist – Director of R&D, Mara Renewables Corp.

At Mara Renewables Corporation, Roberto leads the most advanced R&D program to produce heterotrophic microalgae oil in Canada, including work on genetics, fermentation optimization and downstream processing. His research focuses on critical issues, including yield coefficients, strain development, process scale-up, contamination control, and oil extraction.

He was recognized as the top Ph.D. student in Biological Sciences by his university. He conducted worldwide graduate research: Loughborough University in England, University of Concepcion in Chile, Superior Institute of

Technology in Portugal and National Research Council of Canada. Roberto has extensive experience in biological processes to produce both microbial high-value products and commodities, including carotenoids, nutritional oils and biofuels. He directed the R&D at Ocean Nutrition Canada to produce nutritional lipids from microalgae. Roberto received his B.Eng. in Biotechnological Engineering from the Technological Institute of Sonora, M.Sc. in Biotechnology and Ph.D. in Biological Sciences from the Autonomous Metropolitan University, Mexico.

David Lynch

General Manager, R&D, Enerkem Inc.

David Lynch is General Manager, Research and Development at Enerkem since January 2009. Mr. Lynch has over 15 years of experience in the development of new products and processes, as well as directing facility operations.

Currently, Mr. Lynch manages the operations and activities of Enerkem's pilot and laboratory facilities in Alberta in partnership with the City of Edmonton. Research activities include conversion of heterogeneous waste feedstock to syngas and scalable advanced bio-products as well as greenhouse gas emission reduction.

Enerkem makes biofuels and renewable chemicals from waste. With its proprietary technology, Enerkem converts non-recyclable municipal solid waste into methanol, ethanol and other widely used chemical intermediates.

Mr. Lynch holds a Master of Science degree in Management of Technology from Rensselaer Polytechnic Institute and a Bachelor of Science degree in Chemistry from Fairfield University.

Tim Haig

CEO, Forge Hydrocarbons

Tim is a serial entrepreneur in the Cleantech, Renewable Fuels and Chemical industries.

Currently, Tim is CEO of Forge Hydrocarbons Corporation and CEO of Mara Renewables Corporation. Both Forge and Mara are second generation renewable fuels and renewable chemical companies. Mara is a lipid feedstock company and Forge is a conversation of lipids into Hydrocarbon, invented by Dr. David Bressler of the University of Alberta. Currently, he is also the Interim CEO of Greenmantra Technologies, a post consumer plastic conversion technology to value added chemicals.

Prior to these venture Tim was a founder, Chief Executive Officer and President of BIOX Corporation, a renewable energy company, from 2000 to 2011, and also served as a Director of BIOX Corporation from 2000 to 2012. Prior to co-founding BIOX Corporation, Tim held several senior management positions with high profile organizations both in Canada and the United Kingdom.

Tim also served in the Canadian Forces (Army) for 11 years as an officer.

He received his Master of Business Administration in London, England and his degree as an Industrial Engineer from the Royal Military College of Canada.

Dr. David Bressler

Chief Scientific Advisor, Forge Hydrocarbons

Dr. Bressler is an appointed Professor in the Faculty of Agricultural, Life & Environmental Sciences and the Executive Director of the Biorefining Conversions Network, a provincial organization that was launched in 2009 to coordinate the development of applied technologies in the area of biomass conversion. As Director of the BCN, Dr. Bressler is a strong advocate for taking an integrated, multidisciplinary approach to developing novel, commercializable technologies that will cultivate Alberta's bioindustrial sector.

Dr. Bressler is also the Lead Scientific Advisor of Forge Hydrocarbons Inc., a University of Alberta spin-off company founded based on his patented lipid-to-hydrocarbon technology. He also serves as a Scientific Advisory Board Member for First Green Partners, a $350 M Early Stage venture capital fund in the USA.

After earning his Ph.D. in Microbiology and Cell Biotechnology from the University of Alberta, Dr. Bressler was a Research Manager who lectured two senior courses per year in the Department Chemical and Materials Engineering (University of Alberta) as well as participation at Syncrude Research.

SESSION THREE

THE CORNER OF BIOINDUSTRY ST. AND OIL & GAS AVE.

Dr. Susan Wood-Bohm (Session Chair)

Executive Director, Biological GHG Management Program, CCEMC & Alberta Innovates Bio Solutions

Dr. Susan Wood-Bohm is the Executive Director of the Biological GHG Management Program, which is funded by the Climate Change and Emissions Management (CCEMC) Corporation and delivered in partnership with Alberta Innovates Bio Solutions. The mandate of the program is to discover, develop and deploy technologies that will reduce biological GHG emissions or enhance biological carbon sequestration in the province of Alberta.

Susan holds a Bachelor of Science in Agriculture from the University of Guelph, advanced degrees from Queen's University and an industrial PhD in molecular genetics earned in collaboration with Performance Plants Inc. Before joining Alberta Innovates Bio Solutions, Susan held a faculty position in the Department of Biology and served as the Director of the Office of Research Services at Queen's University. Additionally, she served as the Associate Research Director for BIOCAP Canada Foundation, a not-for-profit research foundation that provided seminal leadership in the areas of climate change and the bioeconomy. Susan is a Fellow of the Queen's University Institute for Energy and Environmental Policy and serves on a number of advisory committee and boards.

Dr. Lisa Dyson

CEO, Kiverdi

Dr. Dyson is the CEO of Kiverdi, a next-generation sustainable oil company that converts CO2 and waste carbon gases into customized oils using the power of biotechnology. Dr. Dyson's technical background began with a PhD in physics from MIT and has included research in bioengineering, energy and physics at Stanford University, UC Berkeley, Princeton University, UC San Francisco, and Lawrence Berkeley National Laboratories. Dr. Dyson was a Fulbright Scholar at the University of London, where she received a Master of Science degree, and has degrees in physics and mathematics from Brandeis University.

Dr. Dyson has broad business experience developing corporate strategies in a number of industries including in packaging, energy, automotive, chemicals, telecommunications, travel, and non-profits. While at The Boston Consulting Group, Dr. Dyson worked with executives at multi-national corporations to help them solve strategic business problems including cutting operational costs, expanding internationally, franchising, developing governance structures, designing effective organizations and developing market entry strategies. Dr. Dyson's entrepreneurial background began when she was on the founding team of an MIT start-up that received funding from Microsoft and later built and led a team that developed a technology that reached millions in volunteering campaigns.

Among her recent accolades, Dr. Dyson was honored to receive a C3E award from MIT and the Department of Energy for her entrepreneurial leadership in energy. She was also the honored this year by the San Francisco Business Times as “One of the Most Influential Women in the Bay Area” for a second year in a row and was previously given their “Forty Under 40” award.

Ian Thomson

President, Western Canada Biodiesel Association

Ian Thomson is a Partner of Waterfall Group. Ian has 25 years’ experience in strategic change, operations and industry development, with expertise in policy implementation, strategic planning, market development and sustainability. Ian was a founder of Canadian Bioenergy Corporation, and as its President 2005-2011 operated a nation-wide biofuel import and distribution business and led a number of first and second generation biofuel and bioenergy project development efforts.

In Waterfall, his research projects have related to biofuel and bioenergy feasibility, markets, trade and policy. During 2013-2014, Ian has worked extensively with NGOs, regulators and elected officials in a coordinating role to connect the BC clean fuels industry to activities in the Pacific Coast that support emerging clean fuels regulations in the state of Washington and Oregon in the Pacific Coast Collaborative.

Prior to Canadian Bioenergy, Ian was a principal in a sustainability consultancy for local energy and sustainability initiatives, and for a decade, a strategy and change management lead for a global Chicago-based consultancy. Ian is also a former Chartered Accountant. He has founded several biofuel industry associations, serving since 2006 as the President of the Western Canada Biodiesel Association.

Neil Shelly

Executive Director, Alberta’s Industrial Heartland Association

Neil Shelly is a native of Alberta and was born and raised in Grande Prairie. Upon receiving his degree in Mechanical Engineering from the University of Alberta he began his career in the Industrial Heartland as a process engineer at the Esso Chemical’s Red Water Fertilizer complex. Upon leaving Esso Chemicals, Neil enjoyed a diverse career as an environmental consultant as well as various positions with the Government of Alberta.

Neil left the Government of Alberta in 1995 to accept the position of Director, Environmental and Technical Affairs with the Alberta Forest Products Association (AFPA) and was appointed to the position of Executive Director in 2002.

In November of 2007, Neil was appointed the Executive Director of the Alberta Industrial Heartland Association where he coordinates economic development and sustainable planning initiatives for the region.

The Alberta’s Industrial Heartland Association is a cooperative effort of the municipalities of the Counties of Lamont, Sturgeon, Strathcona as well as the City of Fort Saskatchewan. Its mandate is to promote and enhance sustainable economic development in the region.

Brad West

*Director, Business Development, Renewable Energy,
Suncor Energy*

Mr. Brad West is currently the Director, Business Development, Renewable Energy at Suncor Energy. Mr. West has over 15 years of experience, primarily in the power generation industry with additional experience in oil and gas and commercial real estate. In his current role, Mr. West's portfolio has expanded to include business development for biofuels. In addition to his experiences in business development and evaluating new investment opportunities, his is also experienced in development engineering, financial modeling and capital investment planning. Mr. West is based in Calgary and has experience in jurisdictions across Canada, the US and Mexico. He holds a Bachelor degree in Electrical Engineering from the University of Saskatchewan and a M.B.A. from the University of Calgary.

Juan Benitez

Senior Specialist, Strategic Partnerships, Cenovus Energy

Juan joined Cenovus Energy (TSE:CVE) in 2012 as a Senior Investment Advisor within the company's corporate venture fund. His current role involves working with the Executive Advisor as a Senior Specialist for Strategic Partnerships as well as managing the Cenovus Environmental Opportunity Fund's investment portfolio. Previously, Juan co-founded and was President/COO of Beyond Compliance Inc., a Calgary-based, venture capital funded enterprise software company with clients in North America and the Middle East. Prior roles include 15 years as an environmental engineer and expert witness on environmental litigation cases.

Juan believes that innovative technology solutions are critical for the energy industry to systemically improve environmental performance. He advocates for leveraging Canada's diverse technical expertise and large talent pool to position Western Canada as a leading global energy technology hub.

Juan is a Professional Engineer, and holds a Bachelor of Applied Science degree from UBC and an M.B.A. from the Haskayne School of Business.

SESSION FOUR

PLUGGING INTO THE "RECEPTOR" INDUSTRY

Dr. William Orts (Session Chair)

Research Leader, Bioproducts, United States Department of Agriculture

Dr. Orts is Research Leader at the USDA's Western Regional Research Center directing a team that provides biorefinery strategies relevant to the Western United States. Dr. Orts has >30 years of experience in multi-disciplinary research at government, academic and industrial settings, all related to bioproducts and biofuels. He received his B.Sc. (Honours) from Queen's University in Chemical Engineering, and his M.Sc. and Ph.D. degrees from the University of Toronto while carrying out research on biopolymers. He completed his Ph.D. while working at the Xerox Research Centre of Canada. Dr. Orts has co-authored more than 180 peer-reviewed journal publications, filed 9 patents, and been honored with multiple awards in the field including the USDA's Secretary Honor Award for Outstanding Technology Transfer.

Dr. Aaron Thornton

Global Marketing Manager, Biorenewables, BASF

Aaron is currently the Global Marketing Manager for Biorenewables within BASF's Catalysts Division located in Iselin, NJ. In this role, Aaron is responsible for the strategic and technical management BASF's portfolio of catalysts for biofuels and bio-based chemicals. Prior to BASF, Aaron worked in the field of Intellectual Property Management, and as a Global Product Line Manager within the chemical industry.

Aaron earned his Ph.D. in organic chemistry from Emory University in Atlanta, GA, a B.A. in Chemistry from Knox College in Galesburg, IL, and he is currently pursuing an M.B.A. at the University of North Carolina's Kenan-Flagler Business School.

Joseph Matt

Technology Development Specialist, Croda, Inc.

Joe Matt is a member of Croda's Technology Investment Group at Croda, Inc. His responsibilities include scouting North America for potential licensing, collaboration and merger & acquisition opportunities. Before taking on this role, Joe worked as a synthesis chemist in Croda's Personal Care Research & Development group. Joe's educational experience includes earning a Bachelor's Degree in chemistry from the Pennsylvania State University and a Masters of Business and Science Degree from Rutgers University.

Dr. Alexander Thiemann

Manager of Scientific Affairs, Dr. Straetmans GmbH

Alexander Thiemann studied molecular biology at the University of Hamburg (Germany) and at the University of Newcastle upon Tyne (U.K.). He received his diploma at the University of Hamburg in 2007, working on protein characterizations in plant viruses. From 2008 to 2011 he accomplished his Ph.D. studies in the department of Plant Developmental Biology and Biotechnology at the University of Hamburg on the molecular characterization of hybrid vigour in maize and its prediction for applied breeding purposes. From 2012, Alexander carried forward his research as a Postdoctoral Associate on the genetic and epigenetic regulation of hybrid vigour and its prediction in extensive maize breeding populations in co-operation with the University of Giessen and the University of Hohenheim.

In April 2014, Alexander joined Dr. Straetmans GmbH in Hamburg. The company develops and markets chemical raw materials and blends, with an emphasis on alternative preservation, for manufacturers of cosmetic products. Most products are from natural resources and are used in the main brands of certified natural cosmetics. The company's application lab is continuously developing new formulations for cutting edge conventional or natural cosmetic products. A team of scientists, a technical experienced sales force, and a network of distribution partners ensure the company's expertise and presence in over 50 countries around the world. Alexander Thiemann's responsibilities in the company involve the active development, organization and communication of the highest scientific competence held by the company.

Dr. Albert Soley

R&D Project Manager, Lipotec

Albert is a chemical engineer with a Ph.D. in Biotechnology from the Autonomous University of Barcelona. From 2000 to 2006, Albert was a member of a Bioprocess Research group at the Autonomous University of Barcelona, participating in public and private projects comprising optimization of culture conditions for established biological systems and characterization of new systems to be cultured, such as stem cells and differentiated tissue-like cultures.

From 2004 to 2006, he was an assistant professor at the Autonomous University of Barcelona dealing with topics such as Bioreactor Design, Downstream Processes and Bioprocess analysis. From 2006 to 2009, he became a founding partner of Hexascreen Culture Technologies, developing mini-bioreactors for the culture of mammalian cells and its optimization.

Since 2009, as part of the Innovation team at Lipotec SAU (part of Lubrizol corporation), Albert manages research and development projects of cosmetic actives having biotechnological origin (Biointec™ product line), searching bacteria and yeast from interesting origins to be screened for cosmetic activities and developing cosmetic active production processes based on such microorganisms.

Ben Tungland

President, Ostrem Chemical Co. Ltd.

Ben Tungland is President of Ostrem Chemical Co. Ltd. and owns the company along with his siblings, Sarah and Erik. Founded in 1963 by their grandfather, Donald Ostrem, Ostrem Chemical manufactures commercial cleaning products and specialty chemicals for sale through distribution throughout Canada. The types of products include automotive, janitorial, industrial, food plant, farm and dairy, and water treatment. Don't let the statistics fool you -- Ben and his siblings plan to defy the odds that indicate 90% of third generation companies fail. So far so good, as the company has grown by 30% since Ben and his siblings bought it in 2008. Interestingly enough, the Tungland family once briefly considered selling the company and buying a marina to operate together on Pender Island. During that time Ben was completing his M.B.A. at the University of Alberta while working full time at Ostrem Chemical. The family decided to refocus their energies on Ostrem Chemical and forget the idea of the marina.

In addition to his role at Ostrem Chemical Co. Ltd., Ben is also the President of Bentley-Northchem Ltd., which sells commercial dishwash and laundry products and equipment and is Ostrem Chemical's biggest customer. Ben and his siblings own Bentley-Northchem equally but his siblings are not involved in the operations there. Together, his two companies employ 65 people in Alberta and British Columbia.

CLOSING PLENARY

Darrell Bricker

CEO for Ipsos, Global Public Affairs

He's a witty and wise pollster, and seer of things to come.

Dr. Darrell Bricker is the world-travelling CEO of Ipsos Public Affairs, a division of the world's second largest market research firm with offices in 25 countries. He is a frequent guest as a media commentator on political, social and business issues. On the speaking circuit, he's popular at industry, government and academic conferences.

Based in Toronto, Dr. Bricker is also an acclaimed researcher, having being director of public opinion research in the Office of Canada's Prime Minister. Dr. Bricker holds a Ph.D. in political science and a B.A. and an M.A. from Canadian universities.

He engages in dual presentations with fellow pollster John Wright, primarily on "What Canadians Think." In those talks, Darrell opines about Canada's place in the world while John focuses more on trends in Canada.

Dr. Bricker is an active member of the American Association of Public Opinion research, ESOMAR, and Canada's MRIA.

He is a prolific author of best-selling books, including Canuckology, with John Wright, and most recently, The Big Shift: The Seismic Change in Canadian Politics, Business and Culture and What It Means For Our Future, co-authored by John Ibbitson, in which they argue that Canada is becoming polarized with East vs. West, Suburban vs. Urban, Immigrants vs. Old School, and more.

A fervent supporter of Canada's military, Dr. Bricker serves, by ministerial appointment, as the honorary colonel of the historic Queen's York Rangers.

POSTER ABSTRACTS

Value-Add Opportunities From Byproducts Utilization

Opportunities for Integration of Forest By-Products with Conventional Industry

Maryam Akbari, Siddharth Jain and Amit Kumar

Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta T6G 2G8, Canada

Alberta's forest sector produces a significant amount of by-products, most of which are not used. There are limited data on volume, location, characteristics, and potential use. There is also little information on conversion of these by-products to a common intermediate that could be used for the production of fuels and chemicals. The overall aim of this project is to perform a comprehensive assessment of Alberta forest operations by-products in order to identify opportunities for value-added production and improved pathways to market.

By-products such as hemicellulosic fraction of black liquor can be used to produce fuels and chemicals. The tall oil produced in the paper and pulp industry can be used to produce biodiesel. Lignin is another high-value intermediate that can be extracted from black liquor. Lignin and hemicellulose can be used for production of different chemicals. Lignin is the most abundant source of aromatic compounds in nature, and in the case of phenol-formaldehyde resins, in which part of the phenol can be replaced by lignin, is more readily available, less toxic, and less expensive than phenol. In addition, lignin is not biodegradable and so is resistant to traditional biological treatment processes. The rejection of this effluent (containing black liquor and lignin) in nature without any treatment or without extraction of them causes serious environmental damage and is a threat to human health.

The following are the key objectives of the proposed project:

1) Identify the by-product streams (black liquor, terpenes, tall oil, etc.) from Alberta's forest industry.
2) Develop geographical information system (GIS) maps to get a sense of the intensity of the flows of these by-products in Alberta.
3) Look at the potential for the production of intermediates (from forest industry by-products) that can be used in a large-scale biorefinery or a petrochemical refinery for conversion to fuels and chemicals.

Enzyme Assisted Production of Cellulose Nanocrystals from Wood Pulp

Dawit Beyene and David C. Bressler

Department of Agricultural, Food and Nutritional Science,
Agriculture/Forestry Centre, University of Alberta, Edmonton, AB T6G 2P5

Cellulose is an abundant, low cost and renewable raw material used in different industries for various applications. Currently, there are growing interests to produce cellulose nanocrystals (CNCs) from cellulose. These rod like nanoscale particles have high elasticity, tensile strength and unique optical properties. Thus, CNCs are highly applicable as reinforcement material in nanocomposites and for development of colored films. CNCs are commercially produced by acid hydrolysis of cellulose. The acid breaks up and solubilises the disordered regions to glucose and releases the highly crystalline CNCs. The major challenges for the industry are the costs incurred from consuming high acid concentration (64 % H_2SO_4), low product yield (20 %) and loss of glucose in the acid waste stream. Cellulase enzymes also hydrolyse cellulose primarily by breaking down the amorphous regions and subsequently attacking the crystalline structure. This proposed study hypothesizes that if enzyme treatment is used, prior to acid hydrolysis, amorphous regions will be solubilized and a more crystalline cellulose can be recovered. This will reduce the acid concentration and temperature required for acid hydrolysis. The glucose released by the enzymes can be recovered and fermented to ethanol to offset production cost. Treatment of wood pulp with cellulases for 6 hours to 9 days produced wide ranges of glucose (18 to 71 %) and cellulose solid (23 to 73 %) yields. In the next phase of this study, response surface methodology will be used to optimize the acid hydrolysis of the enzyme treated cellulose. An optimum system will be identified based on the generation of high CNC yield using minimum acid concentration, hydrolysis time and temperature. Ethanol yield, from fermentation of recovered glucose, will be evaluated for co-production.

Identification and Valorization of Terpene Biomass from Alberta Forest Processing

Samuel J. Mitton, Robin J. Hamilton, Jeffrey Camacho-Bunquin, Houston J.S. Brown, Jeffrey M. Stryker

Department of Chemistry, University of Alberta, Edmonton, AB T6G 2G2

Developing technologies to transform waste stream products from Alberta forest processing to value added chemicals is of critical importance. In particular, terpene fractions extracted from wood processing presents an attractive target as an underexploited resource. The composition of forest derived terpenes vary from region to region as well as often show high oxygen content with nitrogen and sulfur contaminants, which can lead to undesirable formation of coke during processing. In order to make progress and exploit this feedstock, a better fundamental knowledge of the components present in Alberta forest derived terpenes is necessary. To this end, this presentation will detail the preliminary results in the analytical investigation of the constituents of terpene sourced from Alberta forest. This includes gas chromatography – mass spectrometry and thermogravimetric analysis.

Current methods of commercial hydrodeoxygenation require high temperatures and pressures which hinders the profitability of terpene valorization. Transition metal catalysis utilising base metals (Ni, Co, Fe, Mn), which are abundant and non-toxic, that can mediate carbon heteroatom reduction efficiently under mild conditions remain thus far unknown. Research in the group has shown that the robust properties of heterogeneous catalyst combined with the variability and fine tuning capabilities of homogeneous catalyst is attainable utilizing novel 'nano-scale' cluster complexes featuring phosphoanimido ligands coordinated to base metals. We will show the synthesis of novel surface mimetic base metal catalyst as well as preliminary catalysis results in the effective transformation of terpene model compounds and isolated terpene compounds to value added products under mild conditions.

Production of Renewable Hydrocarbons from Thermal Conversion of Abietic Acid and Tall Oil Fatty Acid

Mehdi Omidghane, Ehsan Jenab, and David C. Bressler

Department of Agricultural, Food, and Nutritional Science, University of Alberta, Edmonton, AB Canada T6G 2P5

In this study, the conversion of tall oil to renewable hydrocarbons through a thermal cracking reaction was investigated. Tall oil is a by-product from the Kraft process in the pulping industry that can be used as a cheap feedstock. In this project, abietic acid and tall oil fatty acids were pyrolyzed separately using a batch micro reactor at high temperature and pressure. A gas chromatograph equipped with a flame ionization detector, thermal conductivity detector and mass spectrometry were used to identify the composition of the products. The reaction products were a mixture of alkane and alkene hydrocarbons, and some amounts of aromatics with two and three benzene rings. The pyrolysis of abietic acid resulted in larger amounts of aromatics. The pyrolysis reaction was conducted at different temperatures. The results showed that by increasing temperature, shorter chain hydrocarbons were produced. However, the amount of aromatics in the product increased. Our study demonstrated that the deoxygenation of the initial compounds proceeded through decarbonylation and decarboxylation, but the mechanism depends on the composition of the feedstock material.

Forest-Based Ash as a Pozzolanic Admixture in Concrete

Parisa Setayesh Gar, Vivek Bindiganavile

Civil & Environmental Engineering Dept., University of Alberta, Edmonton, AB, Canada T6G 2W2

In the present investigation, a feasibility study is made to utilize forest-based ashes as supplementary admixtures in concrete. The forest-based ashes are waste from wood suppliers, typically a mixture of hardwood and softwood bark and fines. In the study reported here, the ash was first characterized for chemical composition and physical properties. Subsequently, the potential for its use as a pozzolanic admixture was examined by replacing Portland cement with the ash variously from 0 to 20% by mass at 5% increments. The concrete so produced was tested in compression and splitting tension. The results show that all four FBA samples had a mean particle size between 100 to 1000 microns, and hence larger than that of the Type GU Portland cement used in this study. X-ray florescence showed that the FBA samples were predominantly composed of CaO and SiO_2, with significant amount of SO_3. As well, it was noted that all samples contained K_2O at levels which exceed maximum limits on alkali oxides allowed by ASTM. This poses serious durability concerns due to potential sulphate attack and alkali-silica reaction. However, from their mechanical performance, an increase was seen in the compressive strength at low ash dosage. The performance at 15% mass substitution of Portland cement with ash was similar to the reference mix with cement alone. As well, there was no significant change found in terms of the tensile strength regardless of the ash content. Based on the findings in this study, the forest-based ash sampled here presents satisfactory short-term mechanical performance but must be examined further for durability issues in concrete.

Pseudomonas putida as a Chassis for the Production of Aromatic Compounds from Pulp and Paper Waste Streams

Michael Esau, Dominic Sauvageau

Chemical and Materials Engineering, University of Alberta, Edmonton, Canada

The success and feasibility of many industrial bioconversion strategies greatly rely on the efficiency and robustness of the microorganisms selected for these processes. While improved or novel pathways are created in microbes under ideal conditions in laboratories, the implementation of these organisms in an industrial context often face major problems and setbacks due to harsh conditions and larger scales of operation. It is with this in mind that we aim to develop a robust bacterial chassis for the production of aromatic specialty chemicals using waste streams from the pulp and paper industry as a feedstock. The bacterium *Pseudomonas putida* S16 is a promising candidate for such an application: it can survive under a wide range of industrial conditions; it has a high tolerance for aromatic compounds, and even some solvents; it has an aromatic efflux pump, facilitating product recovery and downstream processing; and it possesses most of the enzymes required for the production of shikimic acid and cinnamic acid, two aromatics of interest. However, *P. putida* has an important drawback, the strain shows tolerance and even resistance to many antibiotics, which are common tools used in genetic engineering and synthetic biology for the selection of added traits. To circumvent this issue, we propose to tie the addition of foreign genes necessary for the production of aromatic compounds to a gene expressing *Vitreoscilla* haemoglobin (VHb). VHb is a protein facilitating the delivery of oxygen in the bacterial cell, which enables lower oxygen requirements. This approach has two important advantages. Firstly, since *P. putida* is a strict aerobe, selection of modified cells can be based on faster growth at low oxygen concentrations. Secondly, since aeration is often an expensive and limiting factor in bioproduction, the addition of VHb can favour the robustness and economic potential of the bacterial chassis being developed.

Synthetic Biology - Fermentation and Biocatalysis

Engineering Yeasts for the Production of Fatty Alcohols

Bonnie A. McNeil, XiaoDong Liu, Isabella Wong, and David T. Stuart

Department of Biochemistry, 561 Medical Sciences Building, University of Alberta, Edmonton, AB, Canada, L2A 2N6

The fatty alcohols hexadecanol and octadecanol are widely used in the cosmetic industry and find extensive application as platform chemicals; however, these fatty alcohols occur rarely in nature and are produced in low abundance. Currently, the primary source of hexadecanol and octadecanol production is palm oil, which has led to extensive deforestation for palm plantations and competition with the food industry for supply. As such scientists have begun to look for greener solutions focusing on utilizing synthetic biology and metabolic engineering to create microbial factories that are capable of synthesizing fatty alcohols from renewable resources. We have engineered the yeast, *Saccharomyces cerevisiae*, to produce hexadecanol and octadecanol by modifying the pathways for both fatty acid biosynthesis and degradation and expressing an exogenous fatty acyl reductase (FAR) enzyme. The pool of available fatty acyl-CoA substrate for the FAR enzyme was increased by overexpressing a subunit of the fatty acid synthetase complex, FAS1, and uncoupling its expression from negative feedback regulated by the presence of fatty acids. The overexpression of FAS1 was accompanied by a deletion of the *pox1* gene which encodes a fatty acyl-CoA oxidase enzyme that is involved in the first step in the degradation of fatty acyl-CoA molecules. Finally, reduction of the fatty acyl-CoA molecules to fatty alcohols was achieved by expression of the exogenous genes, *tesA* from *Escherichia coli* and *far1* from *Mus musculus*. Together these modifications produced strains capable of yielding up to 194 mg/L hexadecanol and octadecanol after 72 hours in 4L batch fed fermentation experiments. Expression of alternate FAR genes from *Arabidopsis thaliana* produced significantly lower yields of hexadecanol and octadecanol; however, expression of the *At*FAR5 enzyme resulted in almost exclusively in the production of octadecanol, which may simplify necessary downstream processing. Ideally we would like to express a similar set of exogenous genes and modifications to metabolic pathways in the oleaginous yeast, *Yarrowia lipolytica* which may result in increased yields of fatty alcohols as it is capable of accumulating up to 38% of its dry weight as lipids.

Industrial Factors Affecting the Growth of *Methylosinus trichosporium* OB3b and Its Production of Polyhydroxybutyrates

Jorge Zaldívar[1], Dominic Sauvageau[1], and Lisa Stein[2]

[1] Department of Chemical and Materials Engineering, University of Alberta, Edmonton, AB T6G 2V4
[2]Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9

Considering the impact plastics have on the environment, the demand for economically viable biodegradable polymers is rapidly growing. Polyhydroxybutyrates (PHBs) represent one class of biopolymers in high demand. Their industrial production currently relies on fermenting bacteria using sugars as feedstock. While this natural polymer is easily degraded to innocuous compounds, the use of sugars translates into high production costs and controversy regarding the food vs. chemicals debate. A promising alternative involves using a class of bacteria (methylotrophs) that convert single-carbon (C1) compounds, rather than sugars, to PHBs. By using C1 compounds that are common industrial wastes, such as methane and methanol, these bacteria not only use a cheap feedstock but they can also alleviate the equivalent CO2 emissions of an industry. This study focuses on understanding and optimizing the production of biomass and PHB by one such methylotroph, Methylosinus trichosporium OB3b (OB3b).

A full factorial design with four factors (carbon source, nitrogen source, nitrogen to carbon ratio, age of inoculum) at two levels each was conducted to assess their effect on biomass and PHB yields in OB3b.

Results showed that the first three factors each had a significant effect on final biomass yields.

Significant interaction effects were shown for the combinations of carbon and nitrogen sources, and the carbon source and inoculum age. Additionally, a three-way interaction involving carbon source, nitrogen-to-carbon ratio and inoculum age was shown to be significant. The two-way interaction between carbon source and nitrogen-to-carbon ratio was found to be just outside the significance level selected for the study. Boxplots of the data showed that methane-grown cultures exhibited greater biomass yields compared to methanol-grown ones; this effect being the most important in terms of magnitude. Greater yields, but to a lesser extent, were also obtained when using ammonium rather than nitrate as nitrogen source, and when low nitrogen-to-carbon ratio was used in combination with any other variables. Further analysis is currently underway to determine the impact of these factors on PHB.

Optimizing Methanotroph Growth Conditions for Use in Industrial Applications

Catherine Tays[1], Lisa Stein[1], and Dominic Sauvageau[2]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9
[2]Department of Chemical and Materials Engineering, University of Alberta, Edmonton, AB T6G 2V4

Methane gas, a pollutant significantly contributing to the greenhouse gas effect, is a common by-product or waste from industrial activities. While its release and sequestration is a major concern to both governments and private industries, methane can also serve as a useful and economical feedstock for a specialized class of bacteria known as methanotrophs. These bacteria use methane as both their carbon and energy source. Methanotrophs have long been noted for their immense potential in the field of biotechnology, including for such uses as bioremediation, biotransformation, catalysis, and synthesis of desirable biomaterials and metabolites. The latter serves as the motivation for this project: to optimize the production of value-added products by methanotrophs by incorporating transcriptomic analysis to the development of bioprocessing strategies, essentially using a pollutant as feedstock.

A particular bioproduct of interest native to methanotrophs is polyhydroxybutyrate (PHB), a precursor to next generation bioplastics. This project is aimed at comprehension and optimization of the process of methanotrophic PHB production, involving the analysis and optimization of the cellular regulation and pathways involved in producing PHB in methanotrophs. To accomplish this, global gene expression analysis along bacterial growth and PHB production cycles has begun. This aims to characterize regulation and the triggers of PHB biosynthesis in methanotrophs, a subject that is currently not well elucidated. This not only guides improved culturing strategies (decoupling growth from PHB production) but can also lead to the identification of other metabolites with economic relevance. This approach is vital to optimizing cellular biomass and PHB production, and achieving a cost-efficient means of production. The result will be an industrially applicable and reliable method of PHB generation through the bioconversion of methane effluents. The potential revealed through this project could result in production of materials that are useful to society, non-harmful to the environment, and profitable for both bioplastic producers and industries releasing methane as a by-product.

Characterization of Shikimic Acid Overproducing Yeast Strain for Self-Cycling Fermentation

Roman Agustin[1], Peter Facchini[2], Vincent Martin[3], Dominic Sauvageau[1]

[1]Department of Chemical and Materials Engineering, University of Alberta
[2]Department of Biological Sciences, University of Calgary
[3]Department of Biology, Concordia University

Shikimic acid is a high-value ingredient in the pharmaceutical and cosmetic industries. It is a precursor metabolite in the biochemical pathway that produces aromatic compounds such as tyrosine and phenylalanine. These aromatic compounds are, in turn, intermediates for the production of 2-phenylethanol (2-PE) and phenylpropylamino alkaloid compounds (PA), such as ephedrine and pseudoephedrine, ingredients used in pharmaceutical, cosmetic and healthcare products. Shikimic acid is currently obtained by extraction from the Chinese star anise plant (*Illicium verneum*); a tedious and expensive process. This creates incentives to find more reliable, cheaper means of production. Microbial process engineering – through the application of self-cycling fermentation (SCF) strategies coupled with synthetic biology – provide a cost-effective and environmentally friendly alternative for the sustainable manufacture of this chemical.

Comparative batch studies of native and engineered strains of *Saccharomyces cerevisiae* were conducted using high performance liquid chromatography. The engineered strain, which was modified in a collaborating lab to overproduce shikimic acid, led to shikimic acid yields of up to 0.40 g/L in shake flask cultures and 0.21 g/L in 1-L batch reactors. In comparison, no shikimic acid could be detected in the native strain cultures. It should be noted that the native strain does contain a natural non-optimized version of the shikimic acid pathway.

SCF is an automated, unsteady state, semi-continuous mode of operation, which leads to synchronized cultures and increased specific productivity of multiple biomolecules. In preparation for SCF operation, native and engineered strains have been characterized based on biomass growth rates, glucose consumption rates, selectivity and productivity of shikimic acid, and carbon dioxide evolution rate. These parameters will serve as bases for the development of an optimized SCF strategy, taking into account production rate, selectivity and cellular resource allocation. This study will help create an economically advantageous and sustainable source of shikimic acid.

Aromatic Bioproducts: Assembly of Fermentation-Based Platforms and Establishment of Deep-Sequencing Resources for Biocatalyst Discovery

Xue Chen, Ryan A. Groves, Jillian M. Hagel, Peter J. Facchini

Department of Biological Sciences, University of Calgary, Calgary, Canada

Aromatic compounds represent a diverse class of chemicals used extensively in manufacturing as organic solvents, dyes, and precursors for the synthesis of pharmaceuticals, nutriceuticals and cosmeceuticals. Currently, the majority of aromatic chemicals are manufactured using petroleum as the raw material. Concern regarding the non-renewable nature of petroleum in addition to the pollution generated from aromatics manufacturing processes has raised interest in more sustainable production systems, especially synthetic biology. Synthetic biology involves the transfer of enzymes or whole pathways from organisms naturally making valuable aromatics to scalable fermentation systems relying on renewable energy sources. Plants biosynthesize a vast array of valuable aromatics derived from L-tyrosine (Tyr) or L-phenylalanine (Phe), including the insecticide methylparaben and amphetamine analogues (AAs) such as pseudoephedrine. Methylparaben, a common ingredient in many cosmeceutical products, is found naturally in plants such as the chaste tree (*Vitex trifolia*) and the final enzyme in methylparaben biosynthesis has been cloned from *Nicotiana* species. We have assembled a multigene pathway in *Escherichia coli* using plant and bacterial enzymes to produce methylparaben in fermentation. Although *p*-hydroxybenzoate, the immediate precursor to methylparaben, has long been a focus of synthetic biology efforts, our aim is to go one step further using a unique plant gene to produce a naturally-derived paraben product. The MultiColi expression system was used to assemble three constructs representing five different genes. Inducible expression of all five proteins was confirmed using immunoblot analysis. In addition to parabens, our program focuses on establishing genomics resources for the discovery of biocatalysts involved in pseudoephedrine biosynthesis. Using Illumina-based deep sequencing, we report the development of a BLASTable library and the identification of several gene candidates putatively involved in AA biosynthesis in *Ephedra sinica*.

Optimizing Production of *cis*,*cis*-Muconic Acid in *Saccharomyces cerevisiae*

Shoham Mookerjee and Vincent Martin

Department of Biology, Concordia University, Montreal, Canada

This project outlines the development of a Saccharomyces cerevisiae CEN.PK strain that could be used to produce high levels of aromatic compounds. It involves deregulation of the central aromatic biosynthesis pathway and introduction of a heterologous pathway. The strain will primarily be used to produce cis, cis-Muconic acid (CCM), a precursor to adipic acid used in Nylon 6,6 production. Negative regulation of central aromatic amino acid biosynthetic pathway was alleviated by deleting the native 3-deoxy-D-arabino-heptulosonate-7-phosphate synthase and overexpressing a mutated feedback-resistant version leading to large increases in carbon flux. Penta-functional Aro1 was also deleted with the aim of removing competing reactions from the precursor molecule. The resulting strain, deficient in aromatic amino acid production, was adapted to scavenge aromatics solely from supplemented tryptophan. This strain shows a 10-fold increase in carbon flux and accumulation of 3-dehydroshikimic acid precursor. The addition of the three heterologous genes to produce CCM resulted in a production of 1.68 mg/l of CCM and accumulation of 50 mg/l of the upstream metabolite Catechol. Fermentation and flux balancing is currently being used to push the carbon flux exclusively to CCM.

Accelerated Microbial De-Watering and Consolidation (Biodensification) of Oil Sands Tailings

Julia Foght, Carmen Li and Kathleen Semple

Department of Biological Sciences, University of Alberta, Edmonton, AB Canada
T6G 2E9

Oil sands tailings ponds contain enormous volumes of water, clays and hydrocarbons as stable colloidal suspensions. It takes decades for the clays to consolidate by gravity and for interstitial water to migrate to the surface of the ponds. This delays recovery of water for re-use in ore processing and keeps the tailings inventory volumes high. Alberta Energy Regulator Directive 074 requires that oil sands tailings pond operators address this problem by de-watering tailings and consolidating the clays to increase their shear strength, but chemical and physical methods are expensive and energy-intensive. A biological approach may be feasible as an adjunct to conventional methods, as the ponds harbour hundreds of different indigenous microbial species whose anaerobic activity has been shown to accelerate de-watering and consolidation ('biodensification'). However, this activity is faster if the microbes are stimulated by the addition of fermentable substrates to the tailings. We previously demonstrated tailings biodensification using agri-business wastes using batch 'settling columns', but an actual process would require a flow-through system similar to that used for anaerobic sewage treatment. Here we used algal biomass (a by-product from our industry partner's pilot-scale CO_2 capture project) as the substrate for tailings incubated in an anaerobic bioreactor operated in semi-continuous (draw-and-feed) mode at bench-scale. This provided treated tailings for subsequent analysis of biodensification potential in 2-L settling columns, monitored by measuring pore water recovery and solids volumes.

We observed that whole cell algal biomass stimulated tailings microbes to accelerate pore water recovery and clay consolidation, with 2 weeks retention time being optimum under the conditions used. The volume of pore water recovered from the treated tailings was three-fold greater than that from a control, and nearly two-fold solids consolidation volume was measured during only a few weeks of settling in the columns. Biogenic gases trapped in the treated tailings sometimes escaped by ebullition, bringing bitumen to the water surface; this could be an added benefit by enabling additional recovery of bitumen resource from post-extraction tailings.

As expected, residual substrate in the tailings also resulted in production of methane by treated tailings, with the 2-week samples again providing the greatest methane production. Whereas methane generation and ebullition in situ would contribute to greenhouse gas emissions, its production in a bioreactor could be beneficial if the methane was trapped for use as a clean-burning on-site biofuel.

Thus, biodensification shows promise as a technique to recover pore water for re-use in processing, reduce solids volumes, recover additional bitumen from tailings and to convert a by-product of CO_2 capture into an on-site biofuel.

Chemical Platforms and Advanced Bio-Based Products

Sugar Modified Microparticles: A Sorbent for Naphthenic Acids

Kimberly D. Hyson, Kamar Sahloul, Todd Lowary, Michael. J. Serpe

Department of Chemistry, University of Alberta, Edmonton, AB T6G 2G2

Northern Alberta houses massive tailing ponds, which store aqueous waste by-products as a result of the process employed to recover bitumen from the oil sand deposits. The aqueous waste, or tailing pond water (TPW), houses numerous toxic chemicals including naphthenic acids (NAs) - a complex group of naturally occurring hydrophobic organic molecules that can have adverse and even irreversible effects on their surrounding environment. Our research group has been developing a unique class of colloidal gel particles for the removal of NAs from TPW by utilizing poly(*N*-isopropylacrylamide) (pNIPAM)-based porous microparticles modified with methyl mannose polysaccharides (MMPs). MMPs have been shown to have a high binding affinity for NAs, while pNIPAm-based microparticles have been shown to have a high binding affinity for organic molecules in general. Several pNIPAM-based microparticles modified with MMPS have been developed and their effectiveness to treat TPW was monitored using photometry, which showed a decrease in acute toxicity.

Sugar Modified Microparticles as a System for Extracting Naphthenic Acids from Tailing Pond Water

Kimberly D. Hyson, Kamar Sahloul, Todd Lowary, Michael. J. Serpe

Department of Chemistry, University of Alberta, Edmonton, AB T6G 2G2

Located in northern Alberta are massive tailing ponds which store aqueous waste by-products as a result of the process employed to recover bitumen from the oil sand deposits. The aqueous waste, or tailing pond water (TPW), houses numerous toxic chemicals including naphthenic acids (NAs) - a complex group of naturally occurring hydrophobic organic molecules that can have adverse and even irreversible effects on their surrounding environment. Our research group has been developing a unique class of colloidal gel particles for the removal of NAs from TPW by utilizing poly(*N*-isopropylacrylamide) (pNIPAM)-based porous microparticles modified with methyl mannose polysaccharides (MMPs) which have been shown to have an affinity for NAs. Several pNIPAM-based microparticles modified with MMPS have been developed and their effectiveness to treat TPW was monitored using photometry, which showed a decrease in acute toxicity.

Hemp: Feedstock for Bio-Resin and Bio-Composites

T.S. Omonov and J.M. Curtis

Lipid Chemistry Group (LCG), Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, T6G 2P5

Epoxy resins are an important class of materials, which are used widely in industries such as electrical, automotive, construction and furniture manufacturing because of their excellent chemical resistance, outstanding adhesion, high tensile and compressive strengths, electrical insulation properties, and superior fatigue strength.

At present, the majority of the commercially available epoxy monomers and their resins are derived from non-renewable, petrochemical based feedstocks. The development of cost effective alternatives from renewable resources is desirable and may find many commercial opportunities. Biobased resins made from vegetable oils offer a sustainable alternative to petroleum-based thermoset resins, with overall lower carbon emissions.

A focus of our research has been in developing lipid-based resins and composite materials using cost-effective green technology. In this project, we are evaluating the use of hemp oil as a starting material. Hemp is being grown as an industrial crop for its valuable fiber, which has superior mechanical properties and can be used in many composites and textiles. In contrast, the utilization of the non-edible hemp oil received far less attention.

The overall goal of this research is to produce and test hemp oil based resin systems. These will be evaluated primarily as the inter-fiber adhesive bonding component used in making biocomposites. The possibility of combining hemp fibers with hemp resin is being explored. This allows for more complete utilization of the hemp plant.

Fourier Transform Infrared Spectroscopic Monitoring Epoxidation of Vegetable Oils and Determination of the Hydroxyl Value of Their Polyols

Tavassoli-Kafrani M. H., van de Voort F. R., and Curtis J. M.

Lipid Chemistry Group (LCG), Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, T6G 2P5

Fourier transform infrared (FTIR) spectroscopy was employed to develop rapid methods for monitoring epoxidation process of vegetable oils and measurement of hydroxyl value (OHV) of polyols. In order to monitor epoxidation process, an attenuated total reflection (ATR) FTIR based method was developed. Epoxidation of canola oil was carried out in the presence of hydrogen peroxide and formic acid with the iodine values and oxirane contents of samples determined at different times by ASTM standard methods. The ATR-FTIR spectra were collected and the absorptions of double bonds at (~3008 cm^{-1}) and epoxide groups (~826 cm^{-1}) were plotted against the amounts of iodine value and oxirane contents, respectively, to develop a calibration curve. In order to validate the method, the loss of double bonds and formation of epoxide groups during epoxidation of camelina and flax seed oils were assessed by ATR-FTIR and the values compared to those of the ASTM methods. Good agreement ($R^2 > 0.98$) was obtained between ATR-FTIR results and the standard methods, indicating that the ATR-FTIR method can be used to monitor epoxidation. The method developed OHV is based on the quantitative reaction of *p*-toluenesulfonyl isocyanate (TSI) with hydroxyl groups (OH) present in the polyols. The changes in the absorption of isocyanate functional group in the FTIR spectra (~2235 cm^{-1}) before and after reaction of OH groups with TSI were used to calculate the OHV of polyols. For validation, the OHV of vegetable oil-based polyols were determined by FTIR and AOCS standard method, with excellent agreement ($R^2 > 0.99$) between methods obtained. These FTIR-based methods reduce the time of analysis to less than 10 minutes which facilitates control and optimization of polyols production.

Novel Flocculant System for Densification of Oil Sands Tailings

Lauren G. Mercier, Gurpreet Dhillon, Tizazu Mekonnen, Paolo Mussone, David C. Bressler

Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB T6G 2P6

This project works to provide value-added opportunities to the oil and gas, as well as the agricultural industries in Alberta, which are the two largest sectors in the province. Mature fine tailings (MFT) are a by-product of bitumen extraction and are long-lasting suspensions composed of a mixture of fine solid clay and mineral particles, as well as hydrocarbons suspended in water. In 2009, an estimated 800 million m^3 of MFT formed in Alberta alone. Water from the dispersions can be recovered by addition of flocculants, which cause the particles to agglomerate and sink to the bottom of the mixture. However, these chemicals, which can be organic polymers (polyacrylamide) or inorganic salts, are often toxic and non-biodegradable. The agricultural industry in Alberta has suffered great losses due to bovine spongiform encephalopathy (BSE), commonly known as mad cow disease, which is a neurodegenerative disease caused by folded proteins, or prions. In 2007, an enhanced feed ban prohibited any material that may contain prions, known as specified risk material (SRM), from use in animal feed, fertilizer and pet foods. SRM must now be disposed of by land filling or incineration at a cost of $75-200/tonne in Alberta. The Bressler group has shown that prions in SRM can be safely destroyed by hydrolysis (according to Canadian Food Inspection Agency protocol), and proteins from this material can be isolated. There are several reactive functional groups on the proteins ($-NH_2$, -OH, -SH, -COOH) that can be utilized for chemical modification and introduction of hydrophobic moieties. We have exploited this to synthesize bio-plastics, composites, adhesives, and foams. Given our expertise with this feedstock, we are now investigating the use of SRM-extracted proteins for the preparation of flocculants. The goal of this project is to develop non-toxic, biodegradable chemical flocculants with proteins extracted from SRM. This project will present flocculation studies of SRM-extracted proteins, chemical modification of the proteins, and propose future work.

Novel Hydrophobic and Hydrophilic Value-Added Compounds from Lignocellulosic Biomass Using Subcritical Fluid Technology for Industrial Applications

Marleny D. A. Saldaña, Thava Vasanthan, and Idaresit Ekaette

Department of Agricultural, Food and Nutritional Science, Faculty of Agricultural, Life and Environmental Science, University of Alberta, Edmonton, AB, Canada, T6G 2P5,

Lignocellulosic biomass has attracted increasing attention due to its vast availability worldwide. In preliminary studies, carbohydrates, and phenolics of potato peel, lentil husk, barley hull, among others were obtained using traditional and subcritical fluid (sCF) technologies in Dr. Saldaña's laboratory (Singh and Saldaña, 2011; Saldaña et al., 2012; Sarkar et al., 2014; Alvarez et al., 2014). Findings in relation to biofilm formation from potato peel and barley husk have also been successful and intellectual property protection has been initiated (International PCT Patent Application No. PCT/CA2014/000432). From our recent publications, it becomes evident that the sCF technology has potential to treat lignocellulosic biomass to generate value-added products. The main goal of the proposed study is to produce value-added compounds from lignocellulosic crop residues, such as spent grain and DDGS with a new cost effective green subcritical fluid technology. The products obtained can have a number of applications in various sectors. Benefits to the Alberta agri-food industry will be to provide a strategy for better utilization of lignocellulosic biomass to recover value-added compounds with tangible industrial applications.

Efficient Conversion of Biodiesel Glycerol to Value-Added Chemicals

Rahul Agrawal, Jianxin Cai, Victoria Russell, and Paul Tiege

Dr. Robert Turner Research Centre (Olds College Centre for Innovation), Olds College, 4500 - 50th Street Olds, Alberta Canada T4H 1R6

Biofuel adoption in Canada is low because of a combination of factors including little government subsidy relative to other countries and unfavourable production economics. A dominant model of biodiesel production in Canada has been that of large manufacturing “refinery” focused on single product delivery – biodiesel – with little value placed on secondary product streams such as glycerol or meal. As the number of biodiesel manufacturers in Canada declines, a different business model may be required if biodiesel production is to remain a valuable part of the bioeconomy.

The proposed initiative is a small, ten month project to evaluate the commercial viability of conversion of biodiesel-derived glycerin to useful, value-added products. Specifically, this project seeks to provide the basis for a practical, locally-sustainable solution to bio-glycerol production. A desired outcome is identification of products and markets that would allow bio-glycerol to be a reliable source of revenue rather than a cost (e.g. tipping fees). Specifically, glycerol sourced from Western Canadian biodiesel manufacturing could be converted to commodity chemicals used in manufacturing or industrial processes that occur in Western Canada (i.e. import replacement offsets) , as drop-ins for existing or proposed industrial process in western Canada, or as a bio-derived alternative for existing product sales from western Canadian companies.

The economic and technological potential and freedom-to-operate landscape of relevant high value conversion strategies will be evaluated. Select conversion strategies with high commercial potential and clear freedom-to-operate will be chosen for lab verification.

POSTER ABSTRACTS

BCN Affiliated Projects

Bio-Based Technologies for a Fossil Fuel Deprived World: Simple Chemistry for Enhancing Natural Fibres for composite applications

Michael George and David C. Bressler

Biorefining Conversions and Fermentation Laboratory, Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton.

The need for technology utilizing less or zero fossil fuel derived material will gradually increase in the future. Bio based technologies for substituting glass fibre and carbon fibre based material has been the focus for the past few decades. Specifically, natural fibre reinforced composites has been regarded as a feasible replacement or supplementation for glass fibre reinforced composites. Natural fibres have inherent better specific mechanical properties when compared to glass fibre, produced from a renewable and possibly abundant source. But, limitations such as limited thermal stability, water uptake and incompatibility with petroleum based resins has bottlenecked the transition from the lab to industry.

As a result, the proposed research covers a simple and fast reaction for enhancing pulp samples treated with readily available iodomethane. Caustic was used to swell the macrostructure of the pulp samples prior to the reaction and aided the production of the nucleophile. Reaction time and concentration of iodomethane were optimized. Pulps samples with significantly hydrophobic surfaces and improved thermal properties were obtained. Also, Fourier transform infra-red spectroscopy and x-ray photoelectron spectroscopy were used to study the changes in chemical functionality and chemical signature abundance respectively. FTIR confirmed the presence of the methyl group and XPS the decrease in the O/C ratio of the surfaces of treated pulps.

In summary, a technology platform, utilizing a simple chemical reagent under organic free conditions was used to enhance the hydrophobicity of pulp samples. Additionally, significant improvements in thermal properties better rendered the pulp samples for processing within the resin temperature window. The proposed technology utilized a novel approach for producing high value and enhanced bio based material for applications in the composite space.

Pipeline Hydro-Transport of Agricultural Residue Biomass: An Experimental and Techno-Economic Study

Mahdi Vaezi, Amit Kumar

Department of Mechanical Engineering, University of Alberta, Edmonton, Alberta, Canada T6G 2G8

Pipeline hydro-transport is considered a more favorable method than truck delivery, since not only benefits from economy of scale, but also relieves the environmental and traffic congestion issues of truck transport. The present research studied pipeline hydro-transport of agricultural residue (lignocellulosic) biomass to conversion facilities, e.g., bio-refinery, in the form of a solid-liquid mixture (slurry). The concept involved knife-milling the agricultural residue (wheat straw and corn stover), classifying into four various size groups, mixing with water over a range of solid concentrations (1.0 to 8.8%) to form a slurry, and finally pumping the slurry using a centrifugal slurry pump through a 25 m closed-circuit pipeline. Through the 5-year course of this research size distributions and morphological features of agricultural residue biomass particles, friction loss and rheological behavior of biomass slurry, and performance of the centrifugal slurry pump handling biomass slurry were investigated.

Agricultural residue biomass particles were found to be of a very diverse nature compared to classic solid particles, e.g., wood chips, sand, coal. Unusual characteristics (e.g., relatively large mean particle size; wide size distribution; extreme shapes; fibrous, pliable, flexible, and asymmetric nature; potential for forming networks) make the particles atypical and give rise to a variety of mechanisms during slurry flow, including drag reduction, that are not often encountered in conventional solid-liquid slurry systems. In this work, uncommon fibrous agricultural residue biomass particles with noticeably large dimensions of 2.0 to 9.0 mm in length and considerably small aspect ratios of 2 to 7 exhibited drag-reducing behaviour. For instance, a 8.8 wt% slurry of <3.2 mm corn stover particles with low aspect ratios of about 3.0 showed a 33% reduction in friction loss with respect to water at the same velocity. Also it was observed that corn stover fibres were generally more effective at reducing drag than wheat straw particles due to distinct morphological features, e.g., irregular surface. In addition, it was proved that by using very small size particles (< 3.2 mm) under known slurry solid concentrations and centrifugal pump operating conditions, it is possible to keep the total head and efficiency of the pump at the same level as the pump handling clear water, and to reduce the power consumption to below that required for pumping water alone.

Based on the experimental results achieved, also a numerical model was developed to predict the friction loss behavior of the agricultural residue biomass slurry as a function of biomass particle type and size, slurry solid concentration, and slurry flow rate. Finally the model was utilized to conduct a techno-economic study on pipeline hydro-transport of agricultural residue biomass, where it was found that the cost of the pipeline hydro-transport could be less than the cost of the truck delivery, above certain capacities and distances though.

The results obtained here could be used to design, optimize, and handle pumps and pipelines in hydro-transport of agricultural residue biomass.

Cellulose Nanocrystals (CNC) Pilot Plant Activities at AITF

Behzad Ahvazi

Program Lead, Biomass Processing & Conversion
BioResource Technologies
Alberta Innovates – Technology Futures

Cellulose nanocrystals (CNC) are natural, biodegradable, and renewable biomaterials, which can be produced by different methods such as acid hydrolysis from a widely available and sustainable cellulosic feedstock. In recent years, the production of CNC has gained considerable interest due to their high crystallinity, high surface area, high aspect ratios, unique morphology and mechanical properties. These features make CNC suitable as high-quality reinforcing filler for nanocomposites, rheological modifier for drilling and fracking fluids, binder and bond strengthener in adhesives, sealants and construction. The production of pilot scale CNC samples represents a critical step for introducing the cellulosic-based biomaterial to industrial markets and provides a platform for the development of novel high value and high volume applications. In 2010, Alberta Innovates - Technology Futures (AITF) was funded through a collaboration of the governments of Canada and Alberta with funding from Western Economic Diversification Canada (WEDC), Alberta Enterprise and Advanced Education (EAE), and financial contributions and 'in kind support' from Alberta-Pacific Forest Industries Inc. (Al-Pac). The objectives were to design and construct a new CNC pilot plant to gain CNC scale-up production knowledge to potential provincial producers, identify applications with sufficient volumes to justify a commercial facility and work with industry towards construction of a commercial CNC facility in Alberta. Kilograms of CNC have been produced and provided to many scientists in several countries for applications development. In this poster, the pilot plant CNC production procedure, typical characteristics and its potential applications development will be presented.

Conversion and Utilization of Byproducts from the Lipid to Hydrocarbon (LTH) Biofuel Production Process

Olga Mameeva, David C. Bressler

Biorefining Conversions and Fermentation Laboratory, Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB T6G 2P5,

Lipids can be used as a feedstock to produce deoxygenated liquid hydrocarbons through a process known as pyrolysis. This is well known alternative to gasification and is becoming an increasingly applicable process for converting different feedstock to solid, gaseous and liquid fuels. New non-catalyzed conversion technology to produce renewable hydrocarbons by the pyrolytic conversion of mono unsaturated fatty acid was successfully established in the Biorefining Conversions and Fermentation Laboratory, University of Alberta. Pyrolysis results in production of a gas phase containing alkanes and alkenes (C_1 to C_5) with concurrent production of CO and CO_2, a liquid phase consisting of alkenes, n-alkanes and fatty acids (deoxygenated hydrocarbons), as well as a solid product of reaction.

The aim of this work is to fully characterize the water fraction (liquid byproduct) from the fatty acid pyrolysis process. The primary objective is to characterize volatile organic acids content, including formic and acetic acids, determination of water (%) and other possible compounds and neutralization of the very acidic pH for subsequent use in fermentations.

The presence of short-chain fatty acids was analyzed on an Agilent 7890 A GC-FID with Agilent 7693 series autosampler and injector with a Stabilwax-BA (RESTEK) column (30 m × 0.53 mm × 0.5 µm). We show that the polar phase byproduct consists of acetic, propionic, butyric and isovaleric acids; the concentrations of valeric, isocapronic, hexanoic and heptanoic acids are very low.

High Activity First Row Transition Metal Catalysts for Hydrodeoxygenation

Robin J. Hamilton, Samuel J. Mitton, Jeffrey Camacho-Bunquin, Houston J.S. Brown, and Jeffrey M. Stryker

Department of Chemistry, University of Alberta, Edmonton, AB T6G 2G2

Recently the journal *Organometallics* featured a roundtable discussion amongst experts in the field of organotransition metal chemistry and catalysis to describe their wish-lists and what they consider to be the state-of-the-art. The general consensus was that first row transition metal systems that have precious metal-like catalytic activity needs to be developed. Current industrial processes typically use second- and third-row transition metal catalysts that are more expensive and toxic than their first-row transition metal counter parts. To this end, we have developed 'surface mimetic' first-row transition metal catalysts that have precious metal like activity, which represents a new paradigm in first-row transition metal catalysis. These 'nano-scale' cluster complexes bridge the gap between heterogeneous and homogeneous catalysis; they contain no bulk-phase, and truly mimic the highly unsaturated corner- and surface cites found in heterogeneous catalysts. Further, these catalysts are capable of a broad range of bond-breaking reactions for hydrotreatment of model compounds, relevant to Alberta's forestry industry waste streams, under exceptionally mild conditions to produce value added products. Perhaps more importantly, these catalysts will break carbon-oxygen bonds efficiently in model lignin compounds, an important advancement towards lignin valorization.

SCBA as a Pozzolanic Admixture in Concrete for Resistance to Sustained Elevated Temperatures

Parisa Setayesh Gar[1], Vivek Bindiganavile[1], and Narayana Suresh[2]

[1]Civil & Environmental Engineering Dept., University of Alberta, Edmonton, AB, Canada T6G 2W2
[2]Building Fire Research Centre, National Institute of Engineering, Mysore, India, 570 008

In the present investigation, a feasibility study is made to utilize the sugar cane bagasse ash (SCBA) as an admixture in concrete and examine its role in imparting resistance under elevated temperatures. The ash was obtained from a sugar mill in India where the bagasse was recycled as fuel for the mill. This ash was characterized for its physical properties and chemical composition. Incorporated as a supplementary cementing admixture, SCBA replaced Portland cement from 0 to 25% by mass fraction at 5% increments. The resulting concrete was subjected to elevated temperatures of 300ºC, 400ºC and 500ºC, exposed for 2 hours in each case. A reference series was examined at room temperature. Compressive and flexural strength were evaluated and compared with the reference performance at room temperature and reported as residual properties. The results show that the SCBA sample had a grain size distribution very similar to that of the Type GU Portland cement used in this study. X-ray florescence showed that this ash was chiefly composed of SiO_2 (>70%). The compressive strength of concrete cubes increases up to 10% SCBA incorporation. Even at 15% cement substitution, it matches that of the reference mix containing Portland cement alone. While there was a consistent drop in the compressive strength at higher temperatures, inclusion of SCBA marginally slows down this deterioration. The flexural strength of concrete containing SCBA was always lower than that seen with Portland cement alone. Once again, the drop was seen to be less significant up to 10% cement substitutions. The findings strongly endorse that bagasse ash imparts resistance to concrete against elevated temperatures and may be used as a supplementary cementing admixture.

Biosynthesis of Butanol and Isobutanol Biofuels

David Stuart, XiaoDong Liu, Ebele Ofuonye, Diana Pham

Department of Biochemistry, University of Alberta, Edmonton, AB, Canada

Contemporary society is heavily dependent upon easy access to cheap and reliable sources of energy for the transportation of people, goods, and services. Most of our transport fuel needs are, and have been met by fuels derived from petroleum. Although petroleum and petroleum based products are highly effective and energy rich sources of fuel they are also non-renewable. Additionally, our heavy use of these fuels has the potential to upset the carbon balance in the environment with consequent changes to global climate patterns.

The biological production of fuels from readily available and rapidly renewable sources has been put forth as a feasible solution to the problem of energy requirements and environmental change. The four carbon alcohols Butanol and isobutanol have garnered interest as potential drop in fuels in that they are capable of replacing gasoline in conventional combustion engines. These alcohols can be blended with gasoline in any proportion, have a greater energy density than ethanol and do not mix with water making them compatible with conventional fuel distribution infrastructure. We have engineered yeast for the production of both of these alcohols and through ablation of the ethanol production pathway and channelling carbon toward production of the desired product we significantly increased the production level of both alcohols. We have tested a series prairie grains and cellulosic hydrolysates as feedstocks for isobutanol production and find that triticale provides the greatest yields, up to 600mg of isobutanol/L. Through continued engineering and strain adaptation we anticipate further increases in yield and the ability to use an increasing variety of feedstocks that will make these fuels economically viable.

Engineering Yeast for the Biosynthesis of Hexanoic Acid from Sugar

David Stuart, XiaoDong Liu

Department of Biochemistry, University of Alberta, Edmonton, Canada

Hexanoic acid is a six carbon carboxylic acid found in low amounts in animal fats. This compound is widely used in the manufacture of esters as artificial flavours and as a platform chemical for the manufacture of a wide range of hexyl derivatives such as hexylphenols. Additionally, at low pH levels it can act as a “green antibiotic”. Industrially hexanoic acid is synthesized as a petroleum by product. As the cost of petroleum increases and easily available sources decrease there is motivation to generate alternative sources of such important chemicals. A small number of microbial strains are capable of synthesizing hexanoic acid under anaerobic conditions, however, in most cases fermentations yield equal of higher concentrations of butyric and other carboxylic acids. Anaerobic digester systems utilizing communities of microbial strains have been generated that produce hexanoic acid with lower concentrations of other carboxylic acids, however these systems require extended time periods (up to one year) to produce large quantities of hexanoic acid.

We have constructed a carbon chain extension pathway modeled on the butanol biosynthetic pathway and installed it in yeast. This strain can ferment glucose to yield hexanoic acid. Initial trials with the production strain displayed yields of up to 156 mg/L from 20g/L glucose. Analysis of fermentation data revealed that hexanoic acid accumulated early in the fermentation but then its concentration decreased as the cells metabolized it. The production strain has since been modified to reduce the ability of the cells to metabolize fatty acids. The production strain is being further modified to channel carbon directly from sugar into hexanoic acid production be deleting the pathway leading to ethanol production and shunting the carbon to acetyl-CoA the starting material for hexanoic acid biosynthesis. This manipulation leads to an increase in intracellular NADH, which drives the hexanoic acid synthesis pathway, in this way improved production of hexanoic acid benefits the cells growth. We anticipate that this strain will be able to produce much higher concentrations of hexanoic acid.

Genetic Engineering to Generate an Industrial Succinic Acid Producing Microbial Strain

David Stuart, XiaoDong Liu

Department of Biochemistry, University of Alberta, Edmonton, Canada

Succinic acid, also known as butanedioic acid, is a dicarboxylic acid that finds extensive application in agricultural, food and pharmaceutical industries. It is a widely used platform chemical that is used in the production of adipic acid, 1,4-butanediol and a variety of biodegradable polymers. Most of the succinic acid used commercially is produced by chemical processes using liquefied petroleum gas (LPG) or petroleum oil is used as a starting material.

Increasing petroleum costs and concerns about climate change have driven an increased interest in the potential to generate microbial systems capable of producing chemicals like succinic acid from low cost biomass. We have investigated the potential of the anaerobic bacterium *Actinobaccillus succinogenes* as a production vehicle for succinic acid biosynthesis. Fermentation reactions using glucose as the feed stock have yielded succinic acid production levels of up to 70 g/L with a yield of 0.8g succinic acid/gram glucose. The goal of this project is to engineer improved succinic acid production through inactivation of key metabolic enzymes that channel carbon away from succinate production and toward ethanol and acetate production. We anticipate that these modifications will enable the production of succinate with an efficiency that will make it cost competitive with that derived from petroleum.

Using Bacteriophages to Prevent Contamination in Yeast Fermentation for Biofuel Production

Juliano Bertozzi Silva, Dominic Sauvageau

Chemical and Materials Engineering, University of Alberta, Edmonton, Canada

The production of biofuels and other bio-molecules is often the result of the conversion of sugars by yeast in a fermentation process. While such processes are well-tested and efficient, contamination by bacteria is common and can greatly jeopardize productivity and profitability. Common methods for preventing contamination include the reduction of mash pH – to slow down the growth of bacteria – and the addition of antibiotics – to kill bacteria. While effective, these methods each have drawbacks: reducing the mash pH leads to lower biofuel yields and slower yeast growth, essentially reducing productivity; the use of antibiotics is costly and can lead to the rise of resistance, which has led many regulating bodies to phase them out altogether. There is thus a need to develop cheap and efficient means of abating contamination in yeast fermentations while retaining high yields of biofuel. The present study investigated the use of bacteriophages – viruses infecting bacteria – as antibacterial agents in yeast fermentations for ethanol production.

The industrial yeast *Saccharomyces cerevisiae* Superstart™, the bacteria *Lactobacillus plantarum* (a common industrial contaminant) and two bacteriophages (B1 and B2) were used in population dynamic studies. Two different media were used: M9 medium – a synthetic medium – and MRS medium – a complex medium favouring the growth of the bacteria. These were tested under aerobic and anaerobic conditions over a wide range of pH (from pH 3 to 7).

As expected, when the yeast was grown in the presence of the bacteria, the yeast cell counts and the ethanol concentration were significantly lower than in pure yeast cultures; a consequence of the competition for the resources available. When bacteriophages were added, individually or in combination, at low multiplicities of infection and at pH 4.5 to 6, bacterial loads were reduced by over 99%. Furthermore, the yeast cell counts and ethanol concentration obtained were the same as in pure yeast cultures. This effect was observed under both aerobic and anaerobic conditions, and in both media tested. Interestingly, the pH conditions at which the bacteriophages were most efficient (pH 5 to 6) also correspond to the optimal pH for ethanol production by the yeast.

Bio-Based Production of a Novel Switchable Solvent

Emily Soon, Archana Parashar, Michael Chae, David C. Bressler

Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton AB T6G 2P5

Switchable solvents are a novel class of chemicals characterized with a unique ability to reversibly switch specific physical properties in response to certain triggers. Of interest are solvents with switchable polarity; under an atmosphere of CO_2, the low polarity solvent is converted to a higher polarity form. The removal of CO_2 results in the reversion of the solvent to low polarity. Switchable solvents have the potential for green use in industrial applications and could replace traditional methods for separating organic solutes from water, a process that is traditionally expensive and energy-intensive. Moreover, because of their novel switchable properties these solvents can be recycled, thus reducing material usage. Currently, industrial application of switchable solvents is limited by commercial availability and difficulty and expense in producing. Hence there is a need for alternative means of producing switchable solvents. One alternative is the bio-based production of switchable solvents using biological conversions of Alberta feedstock. The purpose of this research is to engineer a microbial strain capable of producing a novel switchable solvent during fermentation. The production of the switchable solvent occurs by enzymatic conversion of the primary amine precursor to a tertiary amine that has been previously reported to display switchable properties.

A candidate enzyme with the potential to convert the primary amine to the tertiary amine was identified. The DNA sequence encoding this enzyme was cloned into and expressed in *Escherichia coli*. The activity of the purified enzyme was tested using a univeral assay kit. The enzyme was found to be active on the target primary amine. Future research will focus on determining the extent of enzymatic conversion via analytical chemistry methods.

Development of Fire Extinguisher Foams from Thermal Hydrolyzed Specified Risk Materials

Pooran Appadu, Lauren G. Mercier, David C. Bressler

Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB T6G 2P6

Specified Risk Material (SRM) refers to the tissues in cattle where prions most likely concentrate. Prions are misfolded proteins that cause the neurodegenerative disease of cattle bovine spongiform encephalopathy, or mad cow disease. In 2007, the Canadian Food Inspection Agency introduced an enhanced feed ban on SRM which eliminated its use in all animal feed/food and fertilizer applications. As a result, more than 250 000 tons of SRM in Canada are landfilled annually at considerable economic and environmental costs. Building on the legacy of success of our group in converting SRM into value-added chemicals, this project aims to demonstrate a novel technology platform for the conversion of the peptide extracted from thermally hydrolysed SRM into industrial foaming agents. This contribution will describe the thermal hydrolysis of SRM and subsequent extraction of the peptide component. Foaming performance of the peptide will be presented, as well as methods for enhancing surface and micellar properties.

The Social Science (GE³LS) Component of Genome Canada's POPCAN Project: Prospects and Policies for Genetically Improved Poplars in a Bioeconomy

Jay Anderson and Marty Luckert

Department of Resource Economics and Environmental Sociology
University of Alberta, Edmonton, Alberta T6G 2H1

We explore the socio-economic viability of hybrid poplar as a potential biofuel feedstock. We investigate five areas:

1. ***Policy and Law.*** We identify and review key policies – e.g. property taxation regimes, Crown land policies, carbon markets, and renewable fuel policies – that influence incentives to establish poplar plantations on private and public lands.

2. ***Firm Level Economic Analyses.*** We estimate financial returns from hybrid poplar production to farmers and forestry firms on private and public lands.

3. ***Land Use Change Model.*** We explore competitive advantages of agriculture vs. poplar plantations, influenced by genomic improvements to hybrid poplar and impacts of policies, such as carbon markets and biofuel subsidies.

4. ***Ethics and Public Perceptions.*** We investigate public perceptions regarding establishing poplar plantations for biofuel feedstock.

5. ***Economic Impact Assessment.*** We consider broad social benefits/costs associated with establishing poplar plantations, including impacts on caribou habitat on public land.

Some Key Findings:

1. Policies with large influences on the viability of poplar plantations include Crown land regulations that prohibit exotic tree species and subsidies associated with renewable fuel policies.
2. Financial returns to poplar plantations are lower on private lands (where land costs are high) and higher on public lands (where land costs are low); financial returns are highest for rotations of approximately 20 years.
3. Poplar plantations rarely out-compete agriculture on private lands, but maintaining options to produce pulp and/or biofuels increases their viability.
4. Allowing hybrid plantations on public land is more publically palatable if trees are being used for biofuels; higher levels of genomics knowledge among respondents are associated with greater dis-likes of genomics technology.
5. Allowing exotic plantations on public land could decrease the cost of providing caribou habitat.

ORAL PRESENTATIONS

OCTOBER 23, 2014, 12PM – 1PM

- Hawley Campbell (Graduate student)

  The Evolution of the Canadian Ethanol Industry and the Importance of Economy-Wide Analysis

- Pooran Appadu (Graduate student)

  Development of Fire Extinguisher Foams from Thermal Hydrolyzed Specified Risk Materials

- Dawit Beyene (Graduate student)

  Enzymatic Treatment of Wood Pulp for Cellulose Nanocrystal Production by Acid Hydrolysis

- Roman Agustin (Graduate student)

  Characterization of a Shikimic Acid Overproducing Yeast Strain for Self-Cycling Fermentation

- Bonnie McNeil (Postdoc)

  Using Yeast as Microbial "Factories" for the Production Fatty Alcohols

- Sam Mitton (Postdoc)

  Identification and Valorization of Terpene Biomass from Alberta Forest Processing